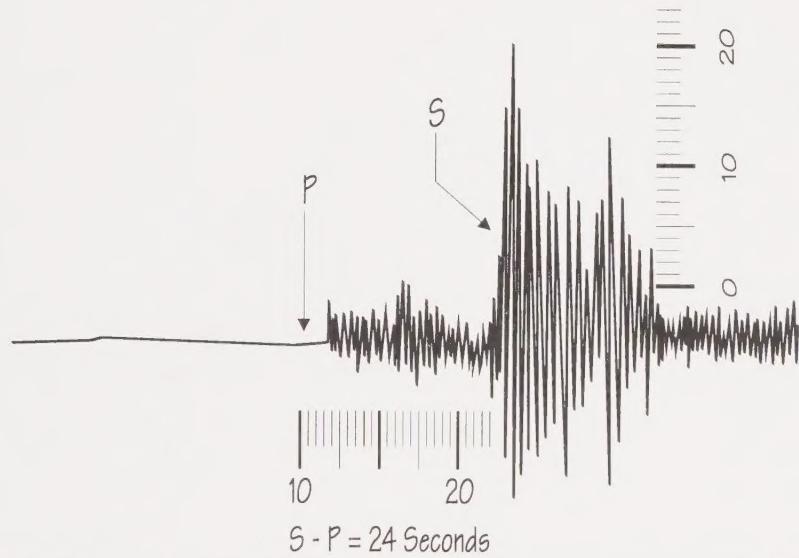


**COMMUNITY SAFETY ELEMENT****SAN FRANCISCO MASTER PLAN**

**PLANNING DEPARTMENT  
CITY AND COUNTY OF SAN FRANCISCO**

**SUMMARY  
BACKGROUND  
REPORT**

February 1996

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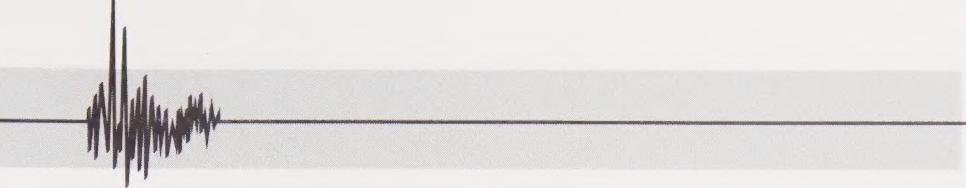
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## COMMUNITY SAFETY ELEMENT

### **SUMMARY BACKGROUND REPORT FEBRUARY 1996**

Planning Department of the  
City and County of San Francisco



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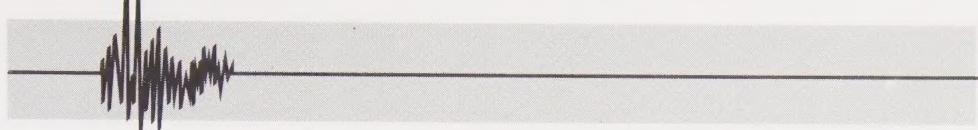
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## INTRODUCTION AND CONTEXT

The purpose of the Community Safety Element is to reduce future loss of life, injuries, property loss and social and economic disruptions from natural or technological disasters. There are several assumptions that underlie this Element:

- *Creating a greater public awareness of the hazards that face San Francisco will result in an informed commitment by public agencies, private organizations and individuals to prepare for future disasters.*
- *Development and implementation of programs to increase safety and to respond to emergencies are the responsibility of many different agencies. Cooperation between City and County agencies, federal and state agencies, non-profit organizations, and the private sector is essential for these programs to be effective.*
- *New development must be undertaken in ways that minimize risks from natural hazards.*
- *Existing hazardous structures have the greatest potential for loss of life and other serious impacts as a result of an earthquake. The City should continue to explore ways to reduce this risk.*

The Community Safety Element focuses on seismic hazards, because the greatest risks to life and property in San Francisco result directly from the ground shaking and ground failure associated with large earthquakes. Other hazards common in other California communities are much less likely to occur in San Francisco, and when they do occur are most likely to be associated with an earthquake. Slope instability is an occasional local hazard, especially in time of heavy rain; widespread damaging landslides are most likely if triggered by earthquake. San Francisco is not subject to flooding of natural waterways. (The National Flood Insurance Program, which designates flood-prone areas, has identified no areas in San Francisco.) Flooding as a result of dam or reservoir failure is unlikely, and is most likely to occur as a result of an earthquake. San Francisco does not have the conditions for large, devastating wild land fires. Urban fires are a constant threat, and the worst case urban fire is conflagration associated with an earthquake. In any earthquake planning scenario, fire suppression is a top priority.



## **THE SAN FRANCISCO MASTER PLAN AND THE COMMUNITY SAFETY ELEMENT**

The State of California requires cities and counties to adopt a “comprehensive, long-term general plan,” containing several required elements. One of these required elements is the safety element, “for the protection of the community from any unreasonable risks associated with the effect of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, and dam failure; slope instability leading to mudslides and landslides; subsidence and other geological hazards . . . ; flooding; and wild land and urban fires.”

San Francisco’s current safety element, called the Community Safety Element, was adopted by the City Planning Commission on September 12, 1974. The Community Safety Element, like all elements of the San Francisco Master Plan, is produced by the Planning Department and adopted by the City Planning Commission, as provided in the City’s Charter. (A new Charter, approved by the voters in November 1995 will change this process. The new Charter becomes effective July 1996.) Once adopted, elements are transmitted to the Board of Supervisors and other decision-makers with responsibilities for determining and carrying out City policy. Achieving the greatest possible preparedness for earthquakes and other natural disasters requires the participation and cooperation of many City departments and agencies, as well as regional, state and federal agencies, non-profit organizations and the private sector.

This revision of the Community Safety Element includes information that has emerged since 1974 as a result of scientific investigation, the City’s experience with the 1989 Loma Prieta earthquake, and other major emergencies here and elsewhere. It reflects changes in the regulatory context of emergency management.

The Community Safety Element needs to be consistent with other Master Plan elements and area plans, as well as with the Priority Policies contained in Section 101.1 of the City Planning Code. Priority Policy 6 is “That the City achieve the greatest possible preparedness to protect against injury and loss of life in an earthquake.” The Community Safety Element seeks to further that policy. It will also provide guidance when new Master Plan elements and area plans, or other City programs, are considered.

## RELATIONSHIP TO OTHER PLANS AND PROGRAMS

### **Emergency Operations Plan**

In addition to the Safety Element, the City is required to adopt and maintain an *Emergency Operations Plan*. The current *Emergency Operations Plan* was completed in 1987. It is being updated and will be presented to the Board of Supervisors for its approval in 1996. The *Emergency Operations Plan* is being prepared by a task force with representatives of City departments and other agencies with responsibilities during emergencies. The task force is coordinated by the San Francisco Office of Emergency Services. This process and the results are described in more detail on page 56.

The *Emergency Operations Plan* describes specific response actions that will be taken by the emergency response agencies, and other City departments in their support, in the aftermath of a disaster, and provides for a coordinated response. The *Community Safety Element* contains broader policies to reduce impacts, occurring over a longer time frame, that will need to be carried out by the City Planning Commission and other City agencies. The *Emergency Operations Plan* implements many of the emergency response policies of this *Community Safety Element*. Both documents address issues related to the recovery from a disaster: the *Emergency Operations Plan* establishes programs and procedures to assure the resumption of daily activities, while the *Community Safety Element* establishes policies to guide the longer-term reconstruction of the City. Both of these documents recognize that a more detailed plan is needed to coordinate efforts to guide the long-term recovery of the City, its residents, and its economic base after a major disaster. Because the *Community Safety Element* and the *Emergency Operations Plan* are being prepared at the same time, attempts were made to coordinate their content, to avoid duplication or contradictions.

### **Hazard Mitigation Plan**

Another required plan is the post-disaster *Hazard Mitigation Plan*. The City prepared a *Hazard Mitigation Plan* after the 1989 Loma Prieta earthquake. It was developed by an inter-departmental team coordinated by the Chief Administrative Officer, and adopted by the Board of Supervisors in 1990. That *Hazard Mitigation Plan* contained similar background information to the



*Community Safety Element*, and a list of earthquake mitigation projects that the City proposed to carry out. The background information about seismic risks included here updates the 1990 *Hazard Mitigation Plan*.

### **Seismic Hazards Study Zones**

In 1990 the California Legislature enacted the Seismic Hazards Mapping Act (Chapter 1168, Statutes of 1990). As a result, the California Division of Mines and Geology (CDMG) is currently mapping Seismic Hazards Studies Zones (SHSZ). A preliminary map showing areas with a potential for liquefaction during an earthquake is being released for local review in mid-1996. That map is shown on page 19. There will be a 90-day period for public review of the preliminary maps. Public comments and recommendations will be received, and a public hearing held by CDMG. After considering comments, the State Geologist will issue official maps. These maps will be posted with the Recorder, the Assessor and the City Planning Commission. This process is described in more detail on page 20.

Within the SHSZs, when development projects are proposed, the proponent is required to conduct a site investigation and prepare a geotechnical report assessing the nature and severity of the hazard, and suggesting appropriate mitigation measures. When approving any project in a SHSZ, the City will use the information and recommendations included in the report to achieve a reasonable protection of public safety.

The City must take the information contained in the maps into account when preparing the Safety Element, or when adopting or revising land use ordinances. Because SHSZ maps are currently being prepared by the CDMG, no new geological research has been conducted for this Safety Element update. CDMG staff have consulted with City staff as the maps are being developed, and have already shared their preliminary information. When the final maps are issued, the Safety Element will be reviewed in light of any new information contained in the official maps. Revisions will be made if appropriate.

## PROCESS

The process of preparing this Community Safety Element began in 1992, when the first of two background reports, *Review of Seismic Information*, was published. That report described the earthquake risks facing San Francisco as a result of its geology, soils and structures. It summarized studies and assessments of the likely impacts of future earthquakes that have been prepared by others. In 1993 a second report, *Earthquake Safety Programs*, described the public and private programs that have been developed to lessen and respond to those risks, focusing on programs of the City and County of San Francisco.

The information in the two earlier reports is summarized, and updated in this volume, *Community Safety Element, Summary Background Report*. A separate volume, *Draft for Citizen Review*, contains proposed Objective and Policies for inclusion in the San Francisco Master Plan. This Draft will be available for public review. It will be considered by the City Planning Commission. After any necessary changes, the Element will be adopted by the Commission as part of the San Francisco Master Plan.

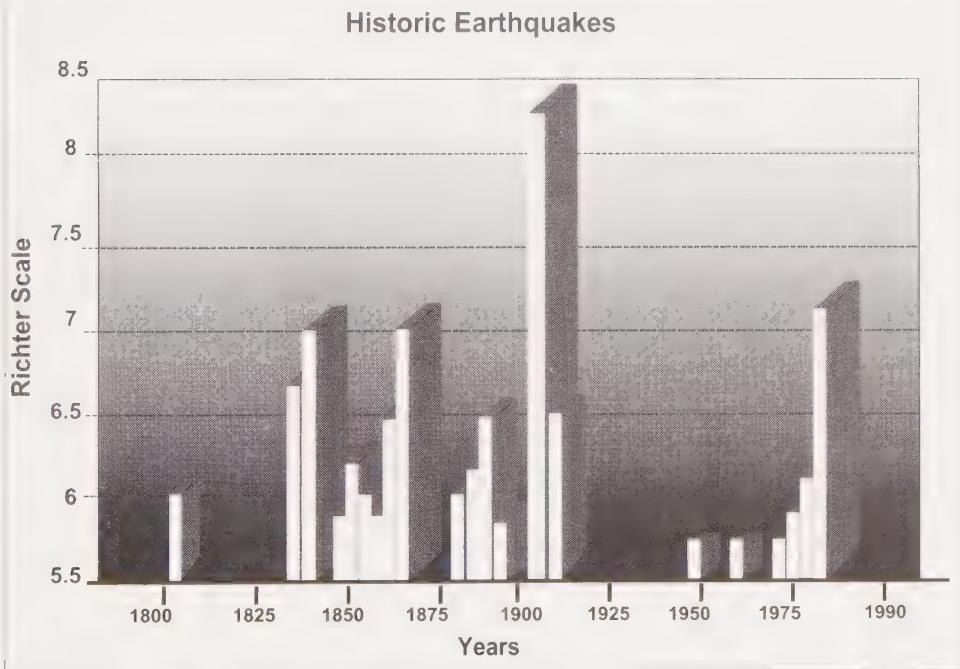




## EARTHQUAKES IN SAN FRANCISCO

Earthquakes have always occurred in the San Francisco area and will continue to occur in the future. There is a historical record of damaging earthquakes dating as far back as 1808. The 1868 Hayward fault earthquake was known as the “great San Francisco earthquake” until 1906. Earthquakes have not, however, been evenly distributed over time. Magnitude 6 to 7 earthquakes were more frequent in the years leading up to 1906 than in the time since then. The great 1906 earthquake released a large amount of pent-up energy along the fault. Consequently, few magnitude 6 or greater earthquakes occurred for many years. Many scientists believe that earthquake frequency since 1979 may represent a return to the higher rates of activity recorded before 1906.

Graph 1



### HISTORIC EARTHQUAKES

The April 18, 1906 earthquake had an estimated magnitude of 8.3. The earthquake caused a large fire, making it difficult to separate earthquake destruction from fire damage. About 26 aftershocks were felt the same day. Recent research shows that deaths numbered as high as 3,000. The worst building damage occurred on “made land”: artificially filled areas created on former marshes, streams and bay. Wood-frame buildings in the South of



### **1906 San Francisco earthquake.**

Photo:  
San Francisco Archives,  
San Francisco  
Public Library



Market area, and brick buildings downtown, were especially heavily damaged. Some buildings with steel frame or reinforced concrete structural systems and with pile foundations (including the Ferry building, the Flood building, the St. Francis Hotel), and some high quality unreinforced masonry buildings survived the earthquake with

substantial but repairable damage. Others, including the City Hall, did not. Large ground displacements in the filled ground along the Bay damaged utilities. Damage to the gas generating and distribution system resulted in explosions and exacerbated the spread of fire. Breaks in the underground water pipes resulted in a loss of firefighting capability. More than 28,000 buildings within a four square mile area were destroyed over a period of three days. About 100,000 people were left homeless. Refugee camps in parks and other open spaces continued for many months. A 1908 estimate of private property damage in the fire zone was \$1 billion. This did not include earthquake damage outside the fire zone or damage to public structures and infrastructure. Some of the municipal bonds that financed the rebuilding of public facilities were not paid off until the 1980s.

The October 17, 1989 Loma Prieta earthquake occurred on the San Andreas fault about 60 miles (100 km) southeast of San Francisco. It had a magnitude of 7.1. Sixty-two people were killed, including eleven in San Francisco. Forty-two of these fatalities occurred because of failures of bridges and freeways. Most of the remaining deaths resulted from the collapse of buildings in Santa Cruz and San Francisco. The total damage to private and public facilities throughout the region is estimated at more than \$6 billion.



The 1989 damage in San Francisco was not evenly distributed through the city. Most of the severe damage occurred in some of the same areas that sustained damage in 1906 – those built on unengineered artificial fill in the Marina and South of Market districts where the nature of the soils resulted in liquefaction and severe ground shaking. Many buildings severely damaged by the earthquake had structural

weaknesses known to make them vulnerable to earthquake damage. They included buildings with “soft stories” (large openings and inadequate strength at the ground story) and unreinforced masonry buildings. About 130 buildings in San Francisco, containing more than 1,000 housing units, were destroyed or irreparably damaged. Many times this number of units were damaged, but repairable. Many could not be occupied for an extended length of time while repairs were carried out. Additional residents were displaced temporarily by a lack of utilities. The Red Cross provided overnight shelter for about 2,000 people on the night of the earthquake. Many more displaced people undoubtedly stayed with friends or relatives.

The transportation and utility systems serving San Francisco were disrupted. While transit systems, notably BART, were able to resume service soon after the earthquake, the freeway and bridge systems remained crippled for considerably longer. The Bay Bridge remained closed to traffic for one month. Some portions of the freeway system were not yet repaired or replaced five years after the earthquake.

**1989 San Francisco earthquake.**

Photo: © 1989 Neil Hart

**TABLE 1 - REGIONAL EARTHQUAKE PROBABILITIES**

By 2010	50%
By 2020	67%

Source: [Probabilities of Large Earthquakes in the San Francisco Bay Region](#), USGS Circular 1053, 1990.

## PROBABILITIES OF FUTURE EARTHQUAKES

Both its earthquake history and geology show that future damaging earthquakes are inevitable in the San Francisco Bay Area. Information on active regional faults and damage patterns from past earthquakes provide important clues about where future earthquake damage will occur. However, the geologic processes that cause earthquakes are not well enough understood for precise prediction of when earthquakes will happen. For this reason, scientists working to understand future earthquakes in the region express their research in terms of probabilities over periods of years.

After the October 1989 Loma Prieta Earthquake, the National Earthquake Prediction Evaluation Council formed a Working Group of earthquake scientists to assess the probabilities of large earthquakes in the Bay Area. The Group's results were published in 1990, *Probabilities of Large Earthquakes in the San Francisco Bay Region, California*, U.S. Geological Survey Circular 1053

The Working Group assessed the likelihood of one or more major earthquakes (magnitude 7 or greater and capable of resulting in substantial damage) in the Bay Area between 1990 and 2020. They concluded that there is a 67% chance that one or more large earthquakes will occur somewhere in the Bay Area by the year 2020. This means that a major quake is twice as likely to occur as it is not to occur. Most of our existing structures and infrastructure, and most of the new buildings and public works now contemplated, will probably be in place when the expected earthquake happens.

The most likely earthquakes to occur, with probabilities over 20%, are magnitude 7 earthquakes on the San Francisco Peninsula segment of the San Andreas fault, on the Southern Segment and the Northern Segment of the Hayward fault, and on the Rodgers Creek fault. Any of these earthquakes could be more damaging in San Francisco than the Loma Prieta earthquake. The most damaging possible earthquake would be a magnitude 8 on the North Coast Segment of the San Andreas fault, similar to the 1906 earthquake. This one is less likely to occur, with a likelihood of 2% by the year 2020.

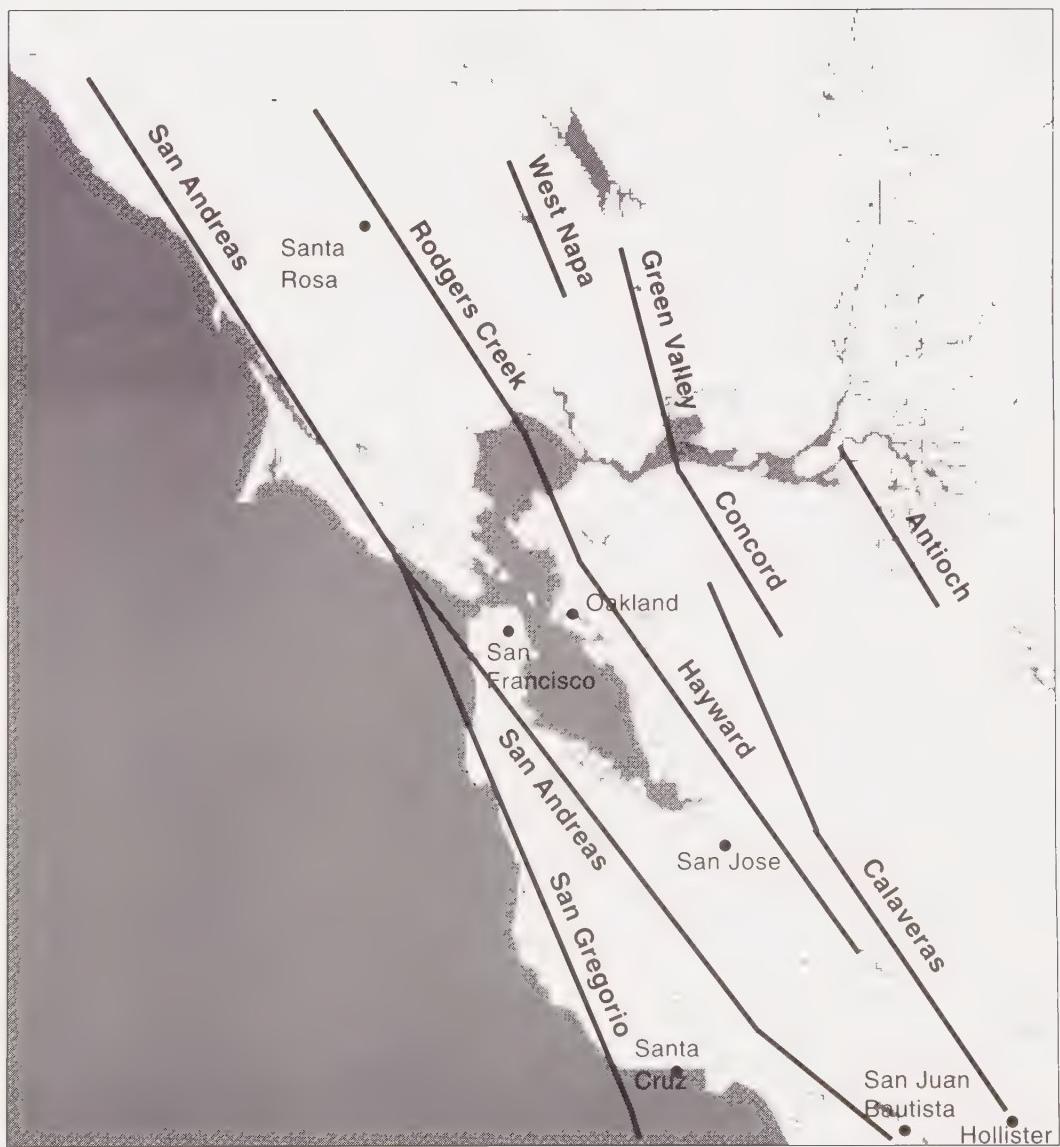
## S A N F R A N C I S C O G E O L O G Y A N D S E I S M I C I T Y

The San Andreas fault system is a complex network of faults that extends throughout the Bay area. (See Map 1.) The faults that make up the San Andreas fault system can often be easily recognized from the air as a linear strip of lakes, bays and valleys. In the Bay area, the San Andreas fault runs through the Crystal Springs Reservoir in San Mateo County, under the Pacific Ocean about one mile west of the southwest corner of San Francisco, and through Tomales Bay. The Hayward fault, which is also part of the San Andreas fault system, runs along the western base of the hills in the East Bay, from San Pablo Bay to San Jose. It is about 10 miles northeast of San Francisco at its closest point. While no known active faults exist in San Francisco, major earthquakes occurring on the faults surrounding the City have resulted in substantial damage within the City. Similar damaging earthquakes in the future are inevitable.

Some of these faults are found beneath or close to the most heavily populated parts of the Bay Area. As a result, earthquakes on these faults could be much more damaging than the Loma Prieta earthquake, even if the magnitude is smaller. The epicenter of the Loma Prieta earthquake was about 60 miles from San Francisco. Had it occurred closer, the damage in San Francisco would have been greater. The Northridge earthquake of 1994 and the Kobe earthquake of 1995 illustrate how destructive earthquakes very close to urban areas can be. The Northridge earthquake, with a magnitude of 6.8 resulted in about 60 deaths and the severe or total damage to about 3000 buildings. The Kobe earthquake had a magnitude of 6.8 and resulted in more than 5,000 deaths and the loss of over 100,000 buildings, including those destroyed by fire.

## S A N F R A N C I S C O S O I L S

The location and movement of earthquake faults do not explain all of the earthquake risk. Even in locations that are relatively far from faults, soils can intensify ground shaking, or the ground may settle or slide. The parts of San Francisco that experienced the greatest damage in 1989 were not those closest to Loma Prieta, but those with soils that magnified ground shaking or lique-



**Map 1**  
**Bay Area Earthquake faults.**

fied. These were the same areas that experienced damage in 1906, though the epicenter of the 1906 earthquake was in a different direction.

The hills along the central spine of the San Francisco peninsula are composed of rock and soils that are less likely to magnify ground shaking, although they are sometimes vulnerable to landsliding during an earthquake. The soils most vulnerable during an earthquake are in low-lying and filled land along the Bay, in low-lying valleys and old creek beds, and to some extent, along the ocean.

Much of the City downhill from the central spine of hills and uphill from the Bayside and creekbed Bay mud deposits consists of fairly flat dune sands, deposited by wind action between 10,000 and 100,000 years ago. This sand shakes during earthquakes more than the underlying bedrock. If water-saturated, it can liquefy.

### **Bay Mud**

During the last million years the ocean level has risen and receded at least four times because of the formation and melting of glaciers. Areas along the Bay shore are underlain by soft Bay mud: a geologically young mixture of sands, clay and gravel deposited during the past 10,000 years following the last period of glaciation. Because Bay mud was deposited relatively recently, it has not been compacted and remains loose. Because of its heterogenous nature, it is not stable, and is more likely to behave erratically when shaken. During earthquakes, water-saturated Bay mud can liquefy and tends to shake considerably more than the underlying bedrock.

In the Marina District the Bay mud is nearly 100 feet thick. During the 1906 earthquake, even before the area had been filled, the Marina District experienced some of the most severe ground shaking in San Francisco because of this layer of Bay mud.

### **Artificial Fill**

The problems of increased ground shaking on Bay mud are compounded by the artificial fill placed above it to extend the buildable land into marshes, lagoons and open water over the last 150 years. It was placed before soils engineering and ground preparation techniques to stabilize fill were developed. As a result this “made ground” shakes more intensely than the underlying bedrock during earthquakes, and, because it is water-saturated, is susceptible to ground failure, particularly liquefaction.





## G E O L O G I C H A Z A R D S

Earthquakes have several distinct effects that can damage structures and disrupt and even endanger our daily lives. An understanding of these natural hazards and how they result in damage can lead to more effective safety planning at a Citywide policy level, and to better decisions about the uses of individual lots.

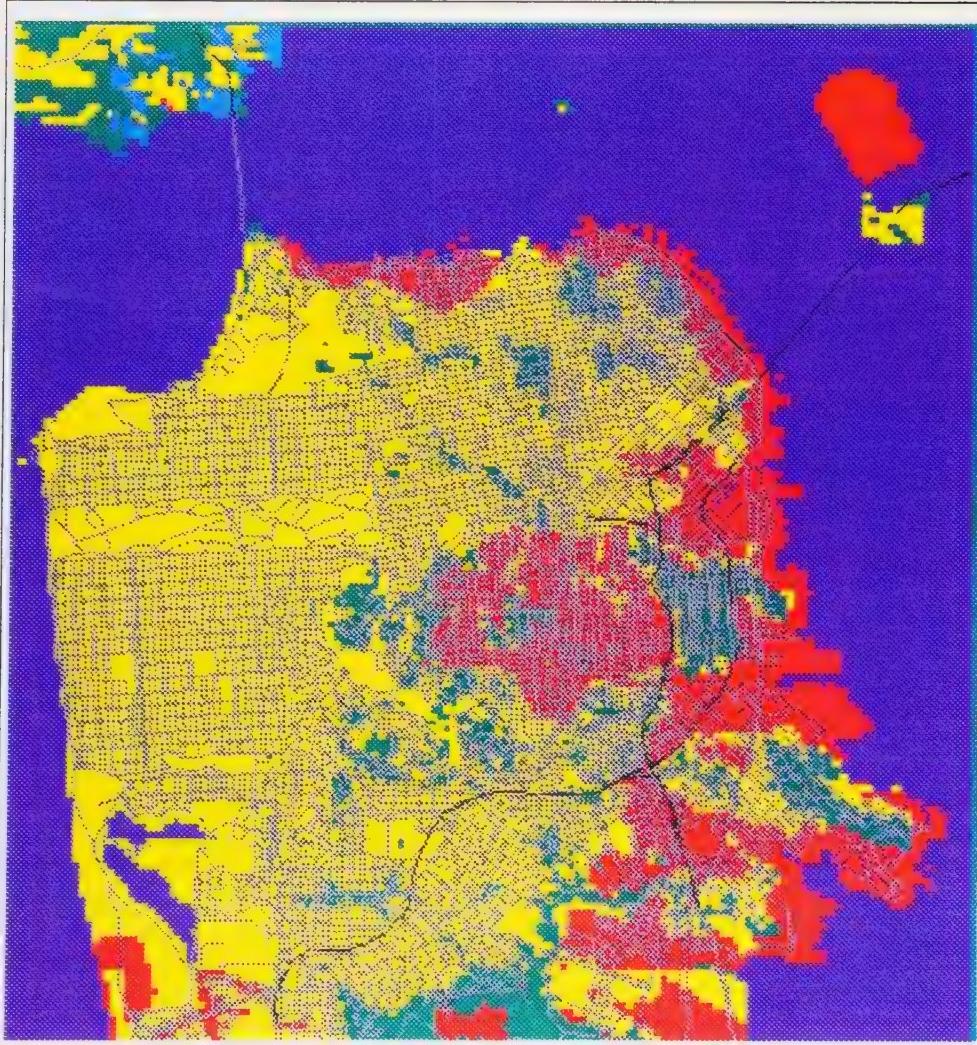
- **Ground Shaking** is the most geographically widespread effect of earthquakes, occurring throughout the region.
- **Surface rupture** may occur directly along the fault.
- **Ground failure** occurs when soil that is saturated with water, is on a slope, or is otherwise weak, cannot support structures, or even itself, after being subjected to ground shaking.
- **Other hazards** that can result from earthquakes include tsunami and seiches.

### GROUND SHAKING

Most earthquake damage comes from ground shaking. Ground shaking occurs in all earthquakes. All of the Bay area and much of California are subject to some level of ground shaking hazard. The impacts of ground shaking will be quite widespread, and are much less predictable than those of surface rupture. The severity of ground shaking varies considerably over the impacted region depending on:

- ▲ the size of the earthquake
- ▲ the distance from the causative fault
- ▲ the nature of the soil at the site
- ▲ the nature of the geologic material between the site and the fault
- ▲ topography

Intensity maps for two of the most probable regional earthquakes, magnitude 7.1 on the Peninsula segment of the San Andreas fault, and magnitude 7.1 on the Northern East Bay segment of the Hayward fault, are shown on **Map 2** and **Map 3**. A comparison of these maps shows that the intensities of ground



### SHAKING INTENSITY

San Andreas  
Earthquake

Peninsula Segment

Magnitude = 7.1

Modified Mercalli

Intensity

Damage Level

■	X - Extreme
■	IX - Heavy
■	VIII - Moderate
■	VII - Nonstructural
■	VI - Objects Fall
■	V - Pictures Move

Source: ABAG, 1995

On Shaky Ground

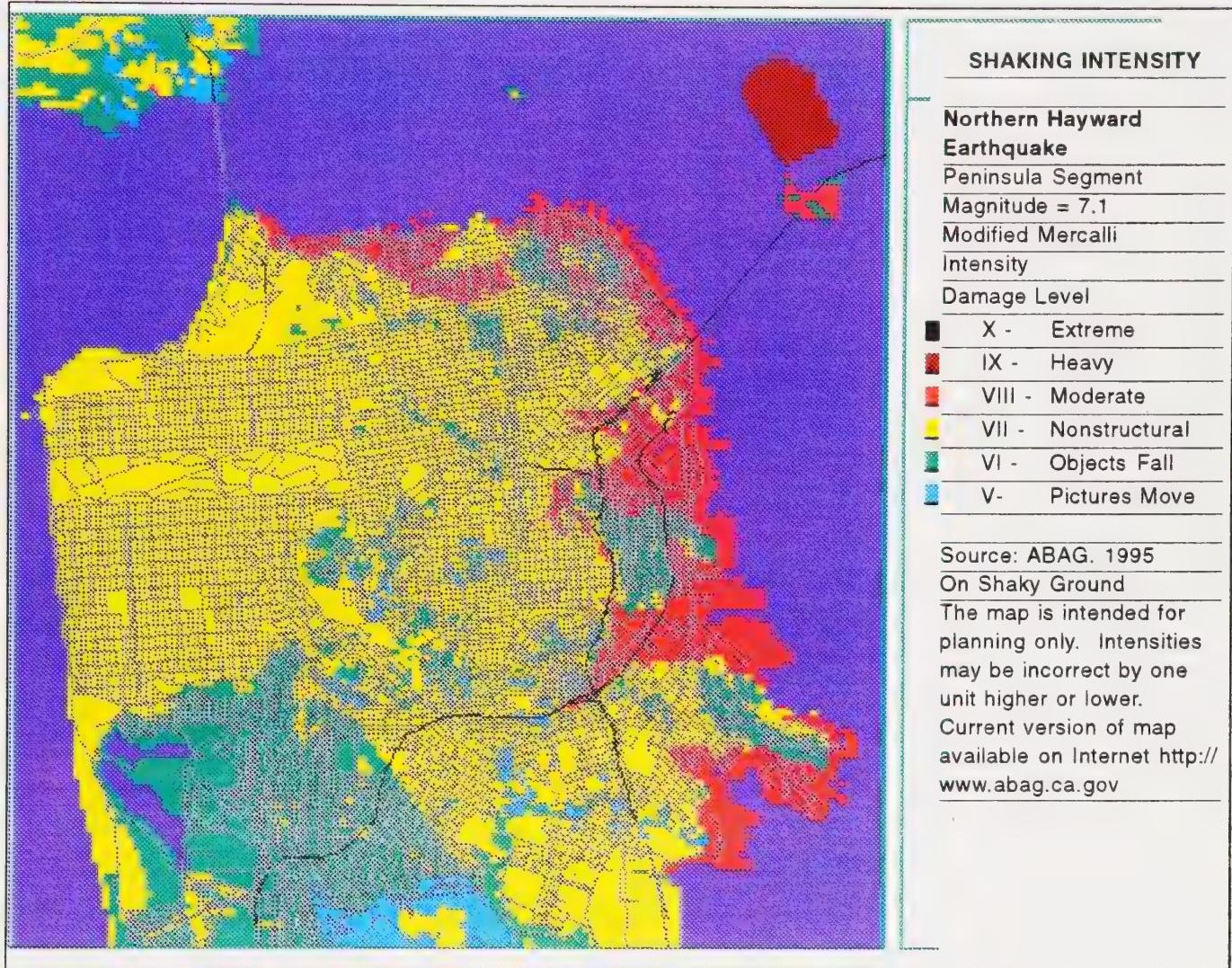
The map is intended for planning only. Intensities may be incorrect by one unit higher or lower.

Current version of map available on Internet

<http://www.abag.ca.gov>

Map 2

Ground Shaking Intensity, Magnitude 7.1 earthquake on the Peninsula segment of the San Andreas fault.



Map 3

Ground Shaking Intensity, Magnitude 7.1 earthquake on the Northern segment of the Hayward fault.



shaking will vary considerably throughout the City during any given earthquake, but the pattern of groundshaking is fairly consistent, reflecting the underlying soil. In general, sites with stronger soil will experience shaking of less intensity than those in low-lying areas and along the Bay, over Bay mud or other weaker soils. Some sites, particularly those with poor soils, will experience strong ground shaking in even distant earthquakes. Sites with stronger soil will experience strong ground shaking only when a nearby fault is involved.

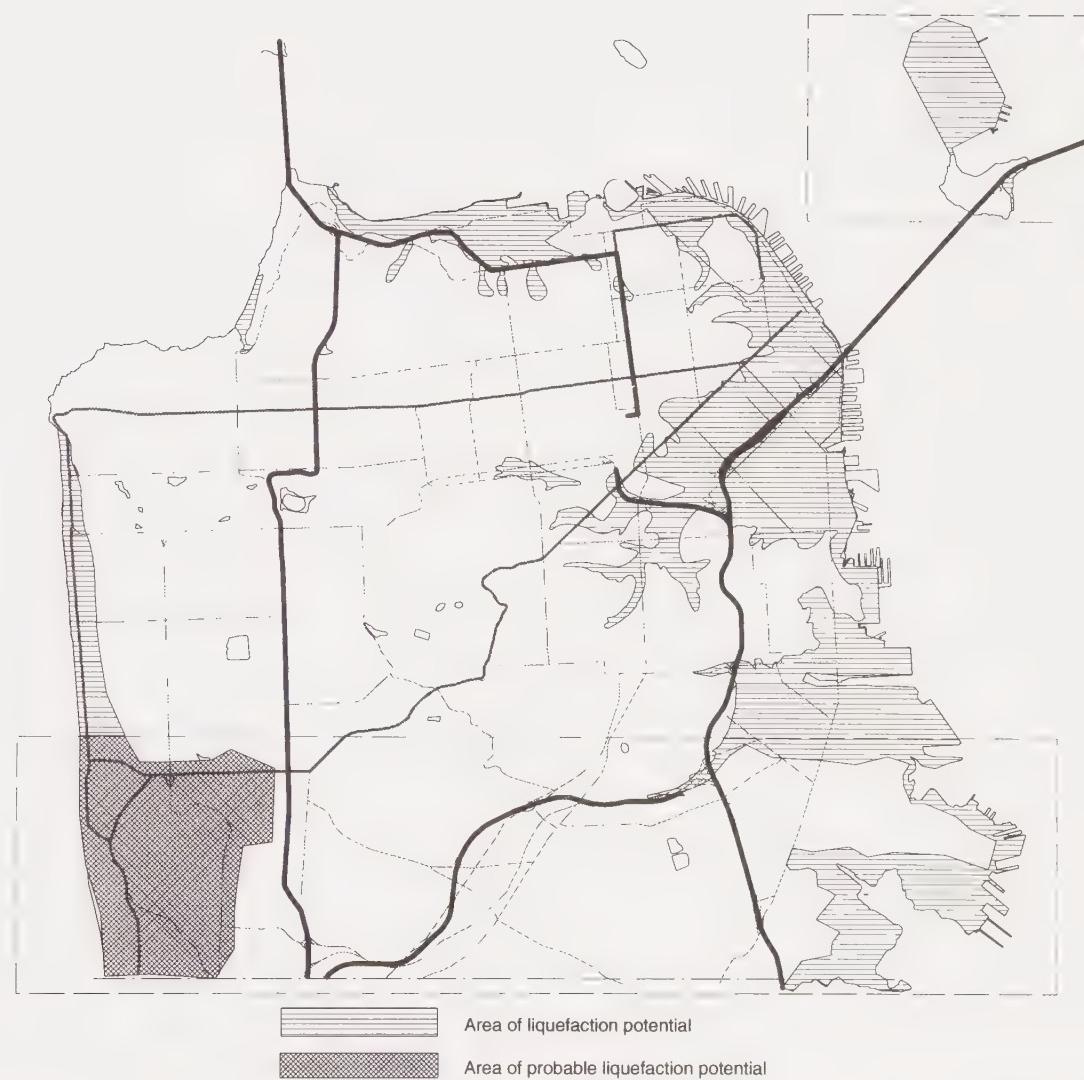
### **SURFACE RUPTURE**

The most obvious and direct earthquake effect is the rupture of the ground surface along the fault. Ground rupture occurs in some, but not all, large earthquakes. Structures are often not able to withstand surface rupture. Streets, utilities and other lifelines that cross an earthquake fault are at great risk of damage. The impacts of fault rupture, while locally severe, are not widespread and are relatively predictable. A state law, the Alquist-Priolo Earthquake Fault Zones Act, identifies active faults and generally prohibits substantial building on top of a known active fault. There are no active faults designated under the Alquist-Priolo program within San Francisco, although the San Andreas fault passes under Daly City and the Pacific Ocean about one mile west of the southwest corner of San Francisco.

A lack of active faults does not mean that San Francisco will be unaffected by fault rupture. The utility and transportation systems serving San Francisco are part of a regional system that will be seriously affected by fault rupture outside of the City, particularly on the Hayward and Calaveras faults.

### **GROUND FAILURE**

“Ground failure” means that the soil is weakened so that it no longer supports its own weight or the weight of structures. The major types of ground failure associated with earthquakes are liquefaction, landslides, and settlement. Ground failure can happen without earthquakes. For example, landslides may be triggered by intense rainfall, changes in the local topography, and/or groundwater conditions.

**Map 4****Seismic Hazards Study Zones - Areas of Liquefaction Potential.**

Sources: San Francisco North Quadrangle, California Department of Conservation Division of Mines and Geology, 1995.  
San Francisco South Quadrangle, URS/John Blume and Associates, 1974.  
Treasure Island, Treadwell and Rollo, 1995.



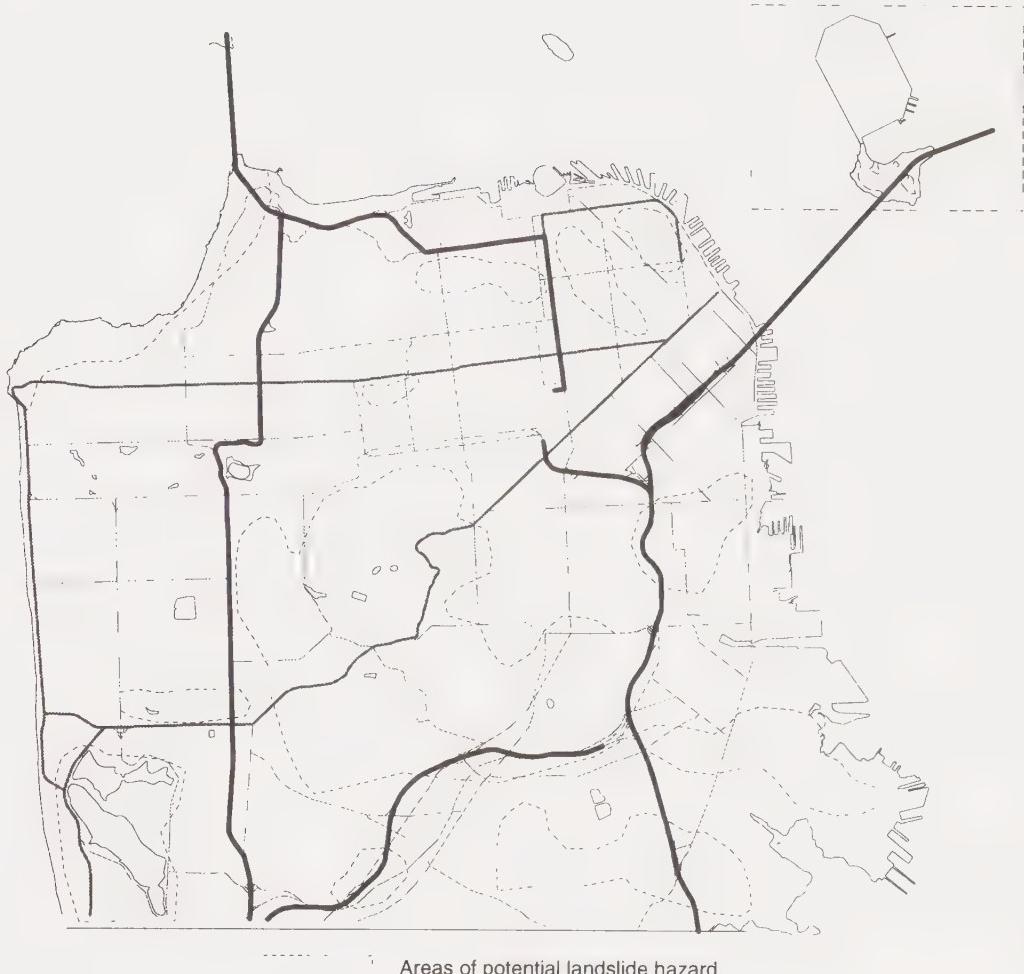
## Liquefaction

*Liquefaction is the transformation of a confined layer of sandy water-saturated material into a liquid-like state because of earthquake shaking. When soil liquefies during an earthquake, water may spout out of the ground, sandboils (sand and water seething from holes in the ground) appear. Ground rupture and lateral spreading may occur. Buried tanks can float to the surface. Structures or parts of structures no longer supported by the soil can tilt, sink or break apart. Underground utilities can be substantially damaged.*

Liquefiable soils in San Francisco usually include uncompressed artificial fill, unconsolidated sand or dune sand, with a high water level. Such soils are generally found in filled areas along the Bay front and former Bay inlets, and in sandy low-lying areas along the ocean front and around Lake Merced.

The California Department of Conservation, Division of Mines and Geology (CDMG) is preparing maps of areas of liquefaction potential, as required by the Seismic Hazard Mapping Act of 1990. These maps, once they are officially adopted, must be used by the City when preparing the Safety Element and when adopting land use plans. Development proposals within the Seismic Hazards Zones shown on the official maps must include a geotechnical investigation and must contain design and construction features that will mitigate any recognized liquefaction hazard.

**Map 4** shows the areas with liquefaction potential. The CDMG mapped the areas in the northern part of the City, within the USGS San Francisco North Quadrangle which includes the north end of the San Francisco peninsula, extending south to about 25th Street and Pacheco Street. This preliminary map will be issued in mid-1996 for public review. After considering any comments received, the State Geologist will issue an official map, which will be posted with the Recorder, the Assessor and the Planning Commission. CDMG also plans to develop a Seismic Hazard Zone Map for the San Francisco South Quadrangle, which includes the southern part of the City, but is not able to estimate when this effort will begin or be completed. The southern part of **Map 4** is from the *San Francisco Seismic Safety Investigation*, conducted in 1974 by John Blume and Associates. The mapping of Treasure Island was done by Treadwell & Rollo as part of the Treasure Island Reuse Planning Process.



### Map 5

#### Areas Susceptible to Landslides

Sources: URS/John Blume & Associates, 1974.

Treasure Island, Treadwell and Rollo, 1995



## Landslides

*A landslide is a movement of a mass of soil down a slope when the soil loses strength and can no longer support the weight of overlying soil or rocks.*

*Landslides may be slow-moving or rapid failures. Landslides are likely to occur suddenly and catastrophically during earthquakes. Areas susceptible to landslides during earthquakes are those where masses of soils are weakly supported because of natural erosion, changes in ground water or surface water patterns, or human activities such as undercutting. Extensive landslides occurred in the Santa Cruz Mountains during the 1989 Loma Prieta earthquake.*

A major earthquake in San Francisco may cause movement of active slides and could trigger new slides similar to those that have already occurred under normal conditions. Areas susceptible to landslides are shown on **Map 5**.

## Settlement

*Settlement (sometimes called subsidence by geologists) is process by which poorly compacted naturally or artificially deposited soils become more compact over time. Soil settles and compacts naturally over geologic time because of gravity and the weight of soil and structures above it.*

*Earthquakes can set off rapid and sometimes uneven local settlement of the ground.*

Settlement under a structure can cause substantial damage. It is most likely to occur in filled areas along the waterfront, where non-engineered artificial fill was deposited over weak young Bay muds. When settlement is uneven, it is especially hazardous to the structures above. Large buildings and facilities such as roads or pipelines, that extend over different types of soil, are the most vulnerable. The areas of potential settlement are similar to, although more limited than, the areas of potential liquefaction.

## INUNDATION

### Tsunami and Seiches

*Tsunami (sometimes incorrectly called tidal waves, even though they have no connection with tides) are large waves in the ocean generated by earthquakes,*

**Map 6****20-foot Tsunami run-up map.**

Source: Maps showing areas of potential inundation by tsunamis in the San Francisco Bay Region, United States Geological Survey, 1972.

*coastal or submarine landslides, or volcanoes. They gather force as they cross long ocean distances. Damaging tsunami are most common in Pacific islands, such as the Hawaiian Islands and Japan, and in Alaska. Bay Area tsunami are likely to be associated with distant earthquakes (most likely those in Alaska or South America), or earthquakes off the Northern California, Oregon or Washington coasts, not with local earthquakes.*



Devastating tsunamis have not occurred in the Bay area. At least 19 smaller ones have been recorded at the Golden Gate; the maximum recorded wave height was about 7.4 feet. A tsunami resulting from the 1964 Alaska earthquake caused considerable damage and ten deaths in Crescent City. There was some damage to boats and marina facilities in San Francisco Bay. Because of the lack of information about the kind of tsunami run-ups that have occurred in the prehistoric past, there is considerable uncertainty over the probability of a Bay Area tsunami, or of the amount of run-up that would be likely to occur. There is ongoing research into the potential tsunami run-up in California. The City and County of San Francisco must keep abreast of new information about the tsunami risk.

**Map 6** shows the areas of potential inundation a tsunami with a 20 foot run-up at the Golden Gate.

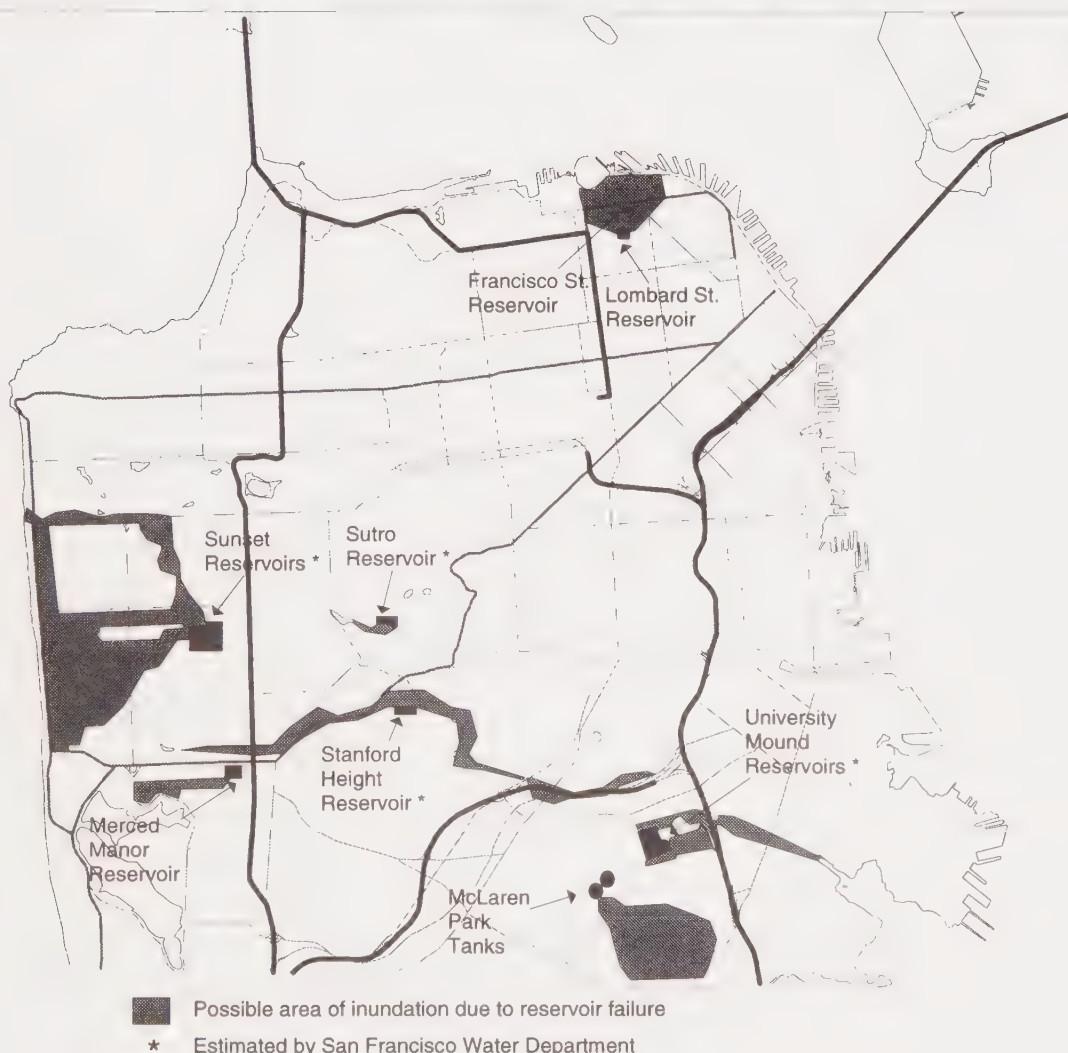
Seiches are periodic waves in closed or semi-closed bodies of water (such as the Bay). In San Francisco Bay, seiches can result from earthquakes on nearby faults. During the 1906 earthquake and the 1965 Alaska earthquake, there was evidence of seiches in the Bay. There has been no evidence of large seiches in the Bay. The maximum likely run-up from a seiche is smaller than the maximum likely run-up from a tsunami.

### **Reservoir failure**

Dams and reservoirs which hold large volumes of water represent a potential hazard due to failure caused by ground shaking. The operation, maintenance and post-earthquake inspection of large dams and reservoirs are regulated by the California Department of Water Resources, Division of Safety of Dams (DOSD). The areas that would be inundated by a total catastrophic failure of these facilities are filed with the California Office of Emergency Services. The San Francisco Water Department owns six reservoirs within San Francisco in this category, including Stanford Heights Reservoir, Sunset Reservoir North and South, Sutro Reservoir, and University Mound Reservoir North and South. Their inundation areas are shown in **Map 7**. Review requirements and in-place drainage facilities at these loca-

tions reduce the probability and extent of inundation. The San Francisco Water Department monitors its facilities by surveying to detect any movement and monitoring ground water, and submits periodic reports prepared by a staff registered engineer to the DOSD.

The Fire Department operates several smaller water storage facilities throughout the City. Their potential inundation areas are also shown on **Map 7**.



Map 7

Inundation URS Areas Due to Reservoir Failure

Source: URS/John Blume & Associates, 1974.

## IMPACTS OF FUTURE EARTHQUAKES

The following section describes the likely impacts of large earthquakes. It is summarized from studies and assessments done by public agencies, engineers and other researchers. It begins with direct impacts on people, proceeds to the physical effects on structures and their contents, related hazards like fire, and concludes with less tangible but very serious economic and social impacts. Because every earthquake is a unique event, estimates of casualties and damage are imprecise and should be used as guides for area-wide planning and policy-making. They are not assessments of particular structures or facilities.

### CASUALTIES

Earthquakes' most profound impacts are deaths and serious injuries. Numbers of casualties largely depend on the number of people in the area at the time and the types of structures that they occupy. Although risk is related to much more than distance from an earthquake fault, it is interesting to note that about 1.26 million people live within 10 km of the likely magnitude 7 earthquake on the Northern segment of the Hayward fault. This is about 10 times the number of people at a similar distance from the epicenter of the Loma Prieta earthquake.

Most deaths and injuries are expected to result from the failure of buildings and other structures. The number of casualties will be influenced by the time of day of the earthquake. At night more people are in relatively safe small wood-frame structures. San Francisco's residential population of about 750,000 is a reasonable estimate of nighttime population. During the day more people could be in more hazardous and higher occupancy buildings, on vulnerable bridges and freeways, or on streets with falling debris. The daytime population of San Francisco consists of residents who do not leave the city for work or other reasons, commuters who enter the area for the day, and visitors. San Francisco's daytime population is about 1.3 million people.

In 1987, the California Division of Mines and Geology estimated a range of 1,500-4,500 deaths from a magnitude 7.5 earthquake on the Hayward Fault. Hospitalized injuries were assumed to be about three times the number of deaths; significant non-hospitalized injuries were estimated at 30 times the number of deaths. A 1995 study by Risk Management Solutions, Inc. and



Stanford University estimated 3,000 to 8,000 deaths resulting from an 8.3 earthquake on the San Andreas fault.

These estimates are very imprecise. Important variables could substantially change the toll. The failure (or lack of failure) of a few high-occupancy or critical facilities such as arenas, theaters, or dams could influence the final casualty count significantly. (For example, had the Cypress structure not failed, Loma Prieta casualties would have been considerably fewer; had another high occupancy structure collapsed there could have been many times the number of deaths.) The degree of water saturation of the ground will influence the occurrence of landslides and the area subject to liquefaction. Weather conditions, especially wind speed and direction, will affect the spread of fire and the ability of emergency responders to control fires.

### **STRUCTURAL DAMAGE**

In addition to the characteristics of the earthquake and of the site (such as the magnitude, duration, soils type), a structure's characteristics including structural type, materials, design, and quality of construction and maintenance will determine how well it will perform. After San Francisco's 1865 earthquake, the front page of a local newspaper observed, "Well-built structures on good ground survived the shaking effects of the earthquake better than structures on made ground. It is a noticeable fact that not one building having walls properly secured and lain in cement, with sound foundations, suffered by the earthquake in the least." This observation has been affirmed in later earthquakes where structurally substantial buildings on good soil have survived.

A complete inventory of San Francisco buildings with structural information does not exist. Some studies have been done which have inventoried subsets of buildings, or have estimated of numbers of buildings. They help identify areas of concern, and topics needing further study.

**Maps 2 and 3** show the expected ground shaking for the most likely earthquakes. During a magnitude 7.1, San Andreas peninsula segment earthquake or a magnitude 7.1 Northern Hayward fault earthquake large parts of the City would experience ground shaking intensity VIII. This will result in structural



damage including damage and partial collapse of some unreinforced masonry buildings, fall of stucco and masonry walls and chimneys, frame houses moved off foundations if not bolted down.

### **Unreinforced Masonry Buildings**

The 1974 Community Safety Element specifically examined pre-1948 masonry- or concrete-bearing-wall buildings with wood floor and roof construction, or unreinforced masonry buildings (UMBs), because of their record of poor performance in earthquakes. Eight deaths during the Loma Prieta earthquake resulted from damaged UMBs. In the Loma Prieta earthquake about 13% of all San Francisco UMBs were damaged to the extent that occupancy was limited, while about 2% of other San Francisco buildings were damaged. During the 1994 Northridge earthquake, UMBs which had been retrofitted pursuant to Los Angeles' UMB ordinance performed better than those which had not. Significant numbers of unretrofitted UMBs suffered partial or complete collapse.

The City is requiring the retrofit of UMBs. As of late 1994, there were about 1750 UMBs in the City, concentrated in the North of Market/Civic Center area, Chinatown, Downtown, and the Bush Street Corridor. A study of a preliminary list of 2100 UMBs in 1985 found that they contained about 21,800 residential units, and about 4,500 commercial enterprises, most of them relatively small. These businesses provide about 46,000 jobs, and provide needed goods and services in their neighborhoods.

The City's program requires the retrofit of all privately owned UMBs by the year 2006. It is being administered by the City's Chief Administrative Officer, and is described on page 50.



**San Francisco  
Unreinforced Masonry  
Building, 1989.**

Photo: Milton Yuen  
San Francisco Fire  
Department



### Other Potentially Hazardous Building Types

There are other building types, in addition to unreinforced masonry buildings, that have not performed well in earthquakes. Buildings of these types exist in San Francisco, although they have not been inventoried.

The most serious hazard, and also the most difficult policy issues, may be posed by non-ductile concrete frame structures. In many of these buildings, the frame was not designed or constructed to allow it to move without fracturing. As a result, they are susceptible to collapse in strong earthquakes. There were many failures of these buildings in the 1971 San Fernando earthquake. Many deaths in the 1985 Mexico City, 1988 Armenia, 1994 Northridge and 1995 Kobe earthquakes resulted from failures of non-ductile concrete frame buildings. Most of the San Francisco freeway viaducts seriously damaged in the Loma Prieta earthquake, and the Cypress viaduct which collapsed in Oakland, were non-ductile concrete structures. Non-ductile concrete frame buildings were constructed as factories, warehouses, or office buildings in the densest parts of the City until the San Francisco building code was changed in 1968 to require ductility. The Association of Bay Area Governments estimates

that more than 30% of the commercial building stock and more than 50% of the industrial building stock of San Francisco is concrete. An unknown but large number of these are of non-ductile concrete. Many of these buildings have historical or architectural value. Because of their larger size and central location, non-ductile concrete frame buildings are often converted to new uses such as offices or residential units. Such conversions may provide opportunities to increase their seismic resistance to collapse during earthquakes.

**Concrete Building, Kobe, Japan, 1995.**

Photo: Catherine Bauman



“Soft-story” buildings, those in which at least one story—often the ground floor—has much less rigidity and/or strength than the rest of the structure, are significant hazards. The 1974 Blume report identified smaller wood-frame buildings with soft stories as having the potential to collapse during an earthquake. During both the Loma Prieta and the 1994 Northridge earthquakes, soft-story residential buildings failed, resulting in deaths.

Small wood-frame residential buildings can be very resistant to earthquake ground shaking, especially if they are bolted to their foundations, and have strong first stories. Wood frame houses without these features, often those built before 1940, can be made much stronger at relatively low cost. Most of San Francisco’s housing stock consists of wood frame buildings which either are, or could easily be, relatively safe structures during earthquakes.

Precast concrete tilt-up buildings have been one of the most hazardous newer building types in strong earthquakes. (They are called “tilt-up” because the exterior concrete walls are formed and poured in a horizontal position and tilted into place with a crane.) The tilt-up came into general use in the early 1960s as an inexpensive industrial structure. Pre-1973 tilt-up structures with insufficient anchoring between walls and roof could collapse during an earthquake. Considerable damage occurred in this type of building in the 1994 Northridge earthquake. There are relatively few of these buildings in San Francisco.



**Sequence of damage to soft-story building in San Francisco, 1989.**

Photo: © 1989 Neil Hart



## **Public Buildings**

General Fund Departments of the City own about 550 buildings, with an average age of more than 50 years and in 1992 estimated replacement value of more than \$4 billion. A 1992 inspection program to identify hazardous City-owned buildings showed that many buildings, including some housing critical services, were likely to suffer serious damage in an earthquake. Loss of these facilities during a major earthquake would clearly reduce the City's ability to provide emergency services during a disaster and to restore non-emergency services after the disaster. The City's Earthquake Safety Program is undertaking the retrofit of these buildings. This program, and the progress that it has made, is described on page 48.

Because of the State's Field Act which regulates school buildings, public schools in San Francisco are probably less susceptible to collapse and disabling damage than other buildings. However, "Early Field Act schools," those built under the provisions of the Act, but before the engineering lessons of the 1970s were integrated into the requirements, may sustain significant loss of function, and may cause injuries to students and teachers during an earthquake.

## **LIFELINES**

Lifelines are physical facilities that deliver vital services to homes, commercial facilities and institutions. They include the utilities that distribute energy and water (both for consumption and firefighting), communications facilities, the transportation system.

The California Department of Conservation, Division of Mines and Geology (CDMG) has estimated the impacts of three possible earthquakes. A 1982 report assesses a magnitude 8.3 earthquake on the San Andreas fault; a 1987 report assesses a magnitude 7.5 earthquake on the Hayward fault; a 1994 report assesses a magnitude 7 earthquake on the Rodgers Creek fault. These "scenarios" project substantial disruption to the lifelines serving San Francisco, including the transportation network. Many principal routes in San Francisco will be subject to major delays and detours, especially those on softer soils. Trans-Bay bridges will be unusable at least during the initial hours. The Hayward fault earthquake would be likely to close the Bay Bridge for



some time due to damage at the East Bay approaches.

San Francisco International Airport is likely to be unusable for major airborne relief operations due to runway damage. After the Rodgers Creek earthquake, it

could be back in operation after about three days. Rail tracks are vulnerable to shaking damage, and tracks are likely to be out of alignment and unusable. BART facilities will be damaged or require safety inspections to the extent that the system will not function for days after a Hayward or San Andreas earthquake, or for hours after a Rodgers Creek earthquake. Pile supported docks, however, are likely to be available for ferry and barge operations.

The CDMG concluded that a large San Andreas earthquake will probably damage electrical power plants and their ancillary facilities, resulting in a reduction in generating capacity of up to 50%. The entire area may be without power, at least temporarily, during some portion of the first 72 hours. After a large Hayward fault event, about 50% of San Francisco customers may be without power for the first day, about 25% for longer. After the studied Rodgers Creek fault earthquake, there would be shorter power outages in San Francisco. During any large earthquake, there will be breaks in the natural gas system, especially in the local distribution lines in areas where liquefaction occurs. This will result in fire hazard.

Telephone communications (including cellular telephones) will be hampered by overloading resulting from many calls being placed and from phones knocked off hooks.

While the aqueducts bringing water into the Bay area are likely to be damaged to some extent by a large earthquake on the San Andreas fault, the area's water storage facilities will probably contain enough water to meet demands



Kobe, Japan, 1995.

Photo: Catherine Bauman



while repairs are made. The CDMG concluded that a Hayward fault earthquake will have greater consequences, with heavy damage to major tunnels, aqueducts, and water distribution systems that cross the fault, resulting in possible long term water shortage. In either earthquake, local water distribution is likely to suffer disruptions, affecting water deliveries in some areas. Many areas will probably be dependent on tanker trucks to provide water. Sewage collection systems and sewage treatment facilities on poorer soils near the Bay are likely to suffer damage, resulting in the discharge of raw sewage into the Bay.

During the 1989 Loma Prieta earthquake many breaks in the municipal water supply system (MWSS) in the Marina district made it unavailable for firefighting. (See page 58 for a description of the Fire Department's alternative water systems) The Fire Department's auxiliary water supply system (AWSS) suffered no pipe ruptures in the Marina district. There were several AWSS pipe ruptures in the South of Market area, which resulted in the loss of

AWSS water in the Marina District. One cistern in the South of Market area failed.

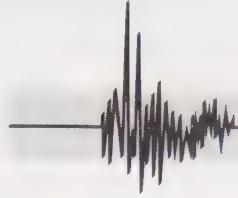
A 1991 study prepared for the Department of Public Works by a consultant group headed by Harding Lawson Associates, examined the potential for liquefaction, and its impacts on the MWSS, the AWSS, and the sewer system in the most susceptible waterfront areas. The study estimated that during a magnitude 8.3 earthquake, (larger than the

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**Water Delivered by  
Tanker Truck, Kobe,  
Japan, 1995.**

Photo: Catherine Bauman





Loma Prieta earthquake), the MWSS will be inoperable in the Marina District, and if the damage is not quickly controlled, it could drain a reservoir which serves other parts of the City in addition to the Marina District. The AWSS in the Marina will likely be inoperable until breaks are found and isolated. As a consequence, the Fire Department would have to rely on the Portable Water Supply System (PWSS), buried cisterns, and the remainder of the AWSS to fight fires.

Following a magnitude 8.3 earthquake, approximately 29,000 feet of sewers are likely to need replacement in these vulnerable areas, at a cost of approximately \$17 million (1991 dollar estimate). Most sewers will continue to function. However, some collapses may cause overflows into the streets.

## **RELEASE OF HAZARDOUS MATERIALS**

Homes, businesses and other facilities contain many materials that, if not properly handled, can result in risks to life, health, or the environment. During a disaster, especially an earthquake, such materials could be accidentally released. The materials that generally pose the greatest hazard during a disaster are those that can, in the form of gas, spread and affect large numbers of people; those that are highly flammable or explosive; and those that are highly toxic or are strong irritants. These materials include ammonia, sulfuric acid, chlorine and sodium cyanide. These types of materials are classified as "acutely hazardous materials" in the California Health and Safety Code Chapter 6.95. As required by that chapter, the San Francisco Department of Public Health regulates the storage and use of acutely hazardous materials to reduce the likelihood of accidental release and off-site consequences. It requires the preparation of a *Risk Management and Prevention Plan* for each site, a detailed plan that includes the response to an on-site or off-site emergency. There are about 45 such permits in the City.

Acutely hazardous materials are found in all areas of the City, although they are somewhat concentrated in industrial areas in the South of Market, the Mission District, the Central Waterfront, and Bayview-Hunters Point area.



Many older structures contain asbestos. If the building is damaged, asbestos may be released into the air in amounts that would not be acceptable in a non-disaster situation. Asbestos mixed with building debris will complicate the removal of debris.

Large earthquakes both lead to release of hazardous materials and reduce the ability of emergency personnel to respond. The number of incidents requiring action will undoubtedly exceed the resources available. Transportation, utility and communication systems needed for response will be disrupted.

## FIRE

A 1987 study prepared for the All-Industry Research Advisory Council (an association of insurers), *Fire Following Earthquake, Estimates of the Conflagration Risk to Insured Property in Greater Los Angeles and San Francisco*, assessed the likely damages of the fires that would occur after a repeat of the 1906 earthquake. The study concluded that under favorable conditions (light winds, average number of fires ignited, quick reporting of fires, and road conditions permitting vehicles to travel 15 miles per hour) the entire Bay region could experience about 570 large fires requiring professional firefighters, nine in San Francisco. About 160 of the fires, including one in downtown San Fran-

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### San Francisco, 1989

Photo: Milton Yuen,  
San Francisco Fire  
Department





cisco, would be very large fires which could not be controlled by one engine. With relatively adverse conditions (winds 20 mph or more, 20% more fires ignited) the entire Bay region would experience about 680 large fires, including 15 in San Francisco. Two of these would be very large fires in the greater downtown.

Under the most favorable conditions, fire losses in San Francisco would be about 6% of the value of all property (\$2.5 billion in damages in 1987). Under more adverse conditions losses would be about 13% of all property value.

The study was conducted before the extension of the AWSS and the creation of the PWSS. It stated that the “implementation of these plans will significantly increase the post-earthquake capabilities of the Fire Department and probably will decrease losses in San Francisco.” See page 58 for a description of these alternative water systems.

## **SOCIAL AND ECONOMIC IMPACTS**

Most earthquake research focuses on damage to buildings and infrastructure, and the resulting deaths and injuries. There will be other, less easily quantified, but still significant losses from a major earthquake.

### **Vulnerable Populations**

Risk of death, injury or displacement because of an earthquake is not evenly distributed. As discussed above, some geographical areas and some types of buildings are much more vulnerable to earthquake damage than others. Some individuals and groups are also more vulnerable, no matter where they live. People who cannot walk easily or have other disabilities may have difficulty negotiating damaged buildings or sidewalks. Those who do not understand English well may not receive important safety information before, during, and after a disaster. People with low incomes are more likely to live in buildings, such as unreinforced masonry buildings that are vulnerable to earthquake damage. They may also be less likely to have stored materials and equipment (such as flashlights and extra food) that will be needed after a disaster, or to have the financial resources to see them through temporary or long-term displacement or unemployment because of an earthquake.



### **Refugees in Jefferson Square, 1906.**

Photo: Bancroft Archives,  
California Office of  
Emergency Services,  
Coastal Region.



### **Loss of housing**

Damage to buildings during an earthquake has effects beyond the immediate life safety concerns and monetary losses. Displacement because of an earthquake can take many forms. Some housing units will be lost forever; the buildings will be destroyed or damaged to the extent that they cannot be repaired. Some units will be repairable, but will not be habitable for an extended time while the work is carried out. Some units may not be structurally damaged, but will be without services for some time. When buildings are destroyed, damaged, or temporarily unusable because of a lack of utilities, residents will need short-term shelters and interim housing while permanent replacement housing is planned and constructed.

This is an especially important issue when housing vacancy rates are low. San Francisco often experiences scarcity of housing, particularly low cost housing, even without a major disaster. A natural disaster will exacerbate problems when there is little vacant undamaged housing available. This was the situation in San Francisco after the 1989 earthquake and after the 1995 Kobe earthquake. Different problems can result when housing vacancies are higher. For example, after the 1994 Northridge earthquake, "ghost towns" developed, areas where housing has not been repaired and may not be for some time because of a lack of demand.

The Association of Bay Area Governments has estimated the number of housing units likely to be, at least temporarily, uninhabitable because of

structural damage from ground shaking in future earthquakes. The analysis considers the intensities of ground shaking, the types and numbers of residential buildings, the differing responses of renters and owners to different levels of damages. The worst case earthquake would be a Hayward fault earthquake involving both the northern and southern segments of the fault. ABAG estimated that this earthquake could result in 157,000 uninhabitable housing units in the region, 41,000 in San Francisco. (In 1990, there were about 330,000 residential units in San Francisco.) These numbers can be used to estimate the number of people seeking shelter in the days immediately following the earthquake, and the number of short-term replacement units that will be needed. ABAG's preliminary estimate is that about 97,000 people would be displaced from their San Francisco homes. Many would stay with friends or relatives, or in hotels. Some would leave the area. About 50,000 people would seek space in public shelters. About half of these people would have been displaced from uninhabitable units. The rest would include people from outside of the City who cannot return to their homes, people who are afraid to use their homes although they may not be hazardous, and those who were homeless before the earthquake. ABAG expects to present the final estimates in spring 1996. By comparison, after the 1989 earthquake, the Red Cross provided shelter for about 2,000 people in San Francisco.

### **Building Loss Issues for Businesses**

Small businesses may be more vulnerable to earthquakes than larger businesses. They are more likely to be located in potentially hazardous buildings, may have less business flexibility than larger businesses, and have less ability to survive the economic disruption of a disaster. They may have little available capital, and are less likely to have alternative business locations.

In addition to loss of buildings, inventory and equipment, business will lose important business-related records and other information. They may suffer a loss of work because of difficulties felt by suppliers, customers or employees. Access to businesses not directly impacted may be difficult.

### **Impact on Historic Resources**

Older buildings are among those most vulnerable to destruction or heavy damage from a large earthquake. Some older buildings do not have the more



### **San Francisco, 1906.**

Photo: Bancroft Archives,  
California Office of  
Emergency Services,  
Coastal Region.



recent engineering features that make buildings more resistant to ground shaking. Because of the history of San Francisco, the areas near the Bay and the historic Bay inlets were among the first parts

of the City to be settled and still contain important historic resources, as well as the most severe ground failure hazards. The part of the City most vulnerable to fire, the dense downtown area, also contains many historic buildings and other structures. A large earthquake will result in a serious and irreplaceable loss of a portion of the historic fabric of San Francisco.

### **Economic Impacts**

Direct damage to structures and lifelines will endanger people, their homes, and the historic fabric of the City, and also represent a substantial economic loss. Structural damage to private and public facilities in the Loma Prieta earthquake resulted in an estimated cost of about \$6 billion to the region. The 1994 Northridge earthquake resulted in an estimated loss of about \$20 billion. In 1980, FEMA estimated that a magnitude 8.3 earthquake on the San Andreas fault could result in \$38 billion worth of property damage (1980 dollars), and that a large Hayward fault earthquake could result in \$44 billion damage. These estimates include private and public buildings, but do not include transportation and communications facilities, dams, utilities installations and special purpose structures.

Beyond structural damage, considerable personal and business property will be damaged. Building contents will be destroyed and damaged. Many vehicles will be destroyed. Businesses may be severely disrupted by power and communications interruptions and transportation difficulties, and by disruptions to their customers and their suppliers. Unemployment is likely to result from business disruption. Shortages of building materials, professional design

services, and contractors may delay rebuilding and raise reconstruction costs, both for homes and businesses.

After a major disaster, considerable financial resources, in the form of grants and loans, from outside the region become available. These programs are intended to help in economic recovery. They will not, however, totally cover the costs of repairs, reconstruction and recovery.

Some, but not most, of the economic losses will be covered by insurance. About 15% to 20% of buildings are insured for shaking losses; almost all are insured for fire. Damage to vehicles is likely to be insured. Many injuries may be covered by health or workers compensation policies. About one-third of commercial property insurance policies contain coverage for business interruption losses.

The Association of Bay Area Governments (ABAG) prepared a study of the macroeconomic impacts of the Loma Prieta earthquake. The study estimates that about 7,100 workers in the region who were eligible for unemployment assistance had been laid off because of the earthquake. These earthquake-related employment impacts lasted about four months. The permanent reduction in the Gross Regional Product (GRP) was estimated at between \$181 million and \$725 million. These regional numbers are not large compared to the total regional economy, representing considerably less than 1% of regional employment, and of the 1989 GRP of \$174 billion. The economic effects were not, however, evenly spread throughout the region. Some areas were much harder hit than others as some economic activity shifted from one county to another.

The ABAG study estimates that San Francisco experienced a loss of between \$31 million and \$73 million in taxable sales in the fourth quarter of 1989 (about 4% of the expected total), and a loss of about 1,100 jobs, largely in the retail sector, because of the earthquake. Some of this loss appears to be the result of a shift in retail activity to other counties in the region. This disproportionate loss in the retail sector in San Francisco was likely due to the reduction in transportation access, illustrating the critical role of transportation and infrastructure in maintaining economic activity.

Although the Northridge earthquake was more damaging than the Loma Prieta earthquake, it occurred in the context of a much larger regional economy. The timing, in economic terms, was also very different. In 1989,



the Bay Area was not yet affected by economic recession. In 1994, Los Angeles was in a severe recession, with high unemployment. The California Governors Office of Planning and Research estimated the economic and employment impacts of the 1994 Northridge earthquake. It accounted for the impacts of a regional shift towards rebuilding at the expense of current and future consumption. It also accounted for the effects of disaster-related payments from government and insurance companies. The study concludes that, after a short initial period of dislocation and small (in relation to the region) job loss, there was a rebuilding phase where employment increased by up to 40,000 jobs (less than 1% of the regional total). After the rebuilding phase comes the financing phase, when people in the region cut consumption to pay for rebuilding, resulting in a loss of up to 60,000 jobs, again less than 1% of the regional total.

A 1995 study by Risk Management Solutions Inc. concluded that a repeat of the 1906 earthquake would result in economic losses in the range of \$170 billion to \$220 billion. At a 1995 conference examining the impacts of a large Hayward fault earthquake, Dr. Tapan Munroe of PG&E estimated that a magnitude 7 earthquake on the Hayward fault would result in about \$4 billion in economic losses, with particular impacts on the region's critical high technology and tourism sectors. Up to 42,000 jobs could be lost, at least temporarily.



## PROGRAMS TO REDUCE IMPACTS OF DISASTERS

The City has programs in place to reduce local disaster risks. Programs and policies of the state and federal governments, and of non-governmental agencies also contribute to the safety of people in San Francisco. These programs are described under three headings, *Hazard Mitigation, Preparedness and Response, and Recovery and Reconstruction*. Some Programs that have been undertaken elsewhere are also described, if they may have some lessons for San Francisco.

***Hazard Mitigation.*** Hazard mitigation programs are intended to reduce or eliminate long term risks. Hazard mitigation activities, effectively carried out, will reduce the need for response and recovery from disasters because they will reduce the amount of physical damage suffered. They often focus on making structures and lifelines (both new and old) more resistant to earthquake damage.

***Preparedness and Response.*** Response activities are the immediate actions taken to save lives, provide care for the injured, protect property, and provide for the basic needs for food, shelter and information in the wake of a disaster. Preparedness programs include planning, education, and training for these actions. Each of these categories includes activities undertaken by emergency responders like firefighters and paramedics, other government agencies, community-based organizations, families, businesses and individuals.

***Recovery and Reconstruction.*** Disaster recovery programs are intended to restore the physical facilities that existed before the disaster, provide assistance for victims, and assist in the economic recovery.





## HAZARD MITIGATION PROGRAMS

### REDUCING HAZARDS IN NEW STRUCTURES

#### **Building Code**

The State of California mandates the local adoption of the California Building Code, based upon the Uniform Building Code (UBC) model code which is prepared by the International Conference of Building Officials (ICBO).

Buildings built to these provisions are expected to resist damage from minor earthquakes, experience some non-structural damage from moderate earthquakes, and suffer some structural damage, but not collapse, from major earthquakes. The UBC is updated annually, as knowledge grows about how structures respond to earthquakes. Unfortunately, the major way that the state of the art is advanced is by observing structures that fail during actual earthquakes. The most extensive building code amendments increasing buildings' structural resistance to earthquakes occurred after the 1971 San Fernando earthquake, as engineers examined buildings that had failed. It is likely that the unexpected patterns of damage that occurred in steel-frame buildings in the 1994 Northridge earthquake will result in changes to the State Building Code.

Local governments can impose more restrictive standards than those in the State code. San Francisco adopts the State code with modifications that concern the resistance to ground-shaking and hillside construction. The San Francisco Building Code is adopted by the Board of Supervisors. It is implemented by the Department of Building Inspection (DBI) which reviews building plans and inspects buildings under construction to insure that they are built as shown on the approved plans and in accordance with codes.

Building codes consider soil conditions only at a very general scale. The 1906 and 1989 earthquakes showed that soils conditions vary enormously throughout the city, and that different soils conditions can result in very different earthquake impacts. Because of the importance of soil conditions, DBI requires and reviews geotechnical reports for projects in areas with susceptibility to ground failure, including liquefaction and landslides. DBI requires that foundations and structural systems be designed that are more likely to survive these hazards. This somewhat informal way of considering soil condi-



tions in the building permit process will soon be formalized pursuant to the new Seismic Hazards Mapping program being undertaken by the State of California. That program is described on page 20.

### **State Requirements for New Buildings**

After the 1933 Long Beach earthquake, the California Legislature passed the Field Act, which mandates seismic resistance in the design and construction of public primary and secondary schools and community colleges. The Field Act, and subsequent laws that broadened and strengthened its provisions, are implemented by the Division of the State Architect, Office of Regulation Services. The ORS reviews plans for new schools and alterations for existing schools. It also inspects construction work done on schools.

For the most part, the Field Act addresses structural safety. Until recently, it did not address the issue of non-structural hazards. The Act does not apply to private schools, or to State colleges and universities.

The 1971 San Fernando earthquake seriously damaged a newly constructed hospital. Since 1973, public, private and state hospitals with state licenses have been subject to standards intended to assure that the facility not only survives an earthquake without collapse, but can continue to function. (This is a considerably higher standard than applies to most buildings.) These laws are implemented by the Office of Statewide Health Planning and Development, which reviews plans and inspects construction work at hospitals. These laws govern the construction of new state-licensed hospitals and alterations to existing hospitals. Many San Francisco hospitals were built before 1973, and may be subject to loss of function after an earthquake. Such failure occurred at some similar hospitals in the Northridge earthquake.

### **REDUCING HAZARDS IN EXISTING FACILITIES**

Many of San Francisco's buildings, other structures, and lifelines were constructed before building codes and construction practices reflected a knowledge of earthquake resistance. Some types of older buildings have performed well in earthquakes, notably well-connected wood frame residential buildings. Other building types have not. Consequently, reducing earthquake impacts requires examining existing facilities and considering the best way to reduce

their hazards. San Francisco, the State of California and utility providers have programs currently underway to reduce these hazards within San Francisco. There remain some large classes of buildings in San Francisco which are likely to suffer severe damage, and to threaten life safety.

Building retrofits are performed to widely differing standards. Some of the public buildings that are being seismically upgraded will meet rigorous current code standards because they are “essential facilities” which need to function after an earthquake. Most buildings which are seismically upgraded meet lower standards than current “new building” codes. These retrofits are intended to reduce but not eliminate hazards. Buildings that are required to be upgraded as part of remodeling work or change of use, described below, are subject to lower minimum required standards of resistance to shaking than the current codes requires for new buildings. Different standards apply in different situations. Historic buildings are eligible to use the State Historic Building Code if the applicable Building Code would result in damage to the historic value of the building. The City’s requirements for seismic upgrade of unreinforced masonry buildings, described below, may not provide the level of lateral resistance that the Building Code requires for other substantially remodeled buildings.

Some building owners, out of concern for safety and for the ability of their buildings to survive earthquakes, or from concerns about liability or insurance, voluntarily choose to upgrade their buildings or choose to exceed minimum code standards. The City of San Leandro has published guidelines, and provides technical assistance to encourage owners of small wood-frame homes to reduce voluntarily their seismic risks. The San Francisco Department of Building Inspection is considering developing such a program, targeting San Francisco buildings.

### **Retrofit requirements triggered by remodeling**

Buildings are generally required to be maintained to meet the building code standards in effect when they were built, even if those standards do not result in the same level of safety that the current code provides. However, when a property owner undertakes remodeling or other alteration that would extensively alter a building structurally or nonstructurally, or change the building’s



use, Sections 104(f) and 2303 of San Francisco Building Code require retrofit to standards which are higher than original construction standards, but below those required for new construction.

### **Parapet Ordinance**

San Francisco has required owners of concrete and masonry buildings, even with no remodeling plans, to reinforce older parapets and other appendages which could, if not securely anchored to the building, pose a collapse or falling threat during an earthquake. The program is largely complete, with more than 90% of the parapets subject to the ordinance reinforced. Structural engineers have credited this parapet strengthening with preventing injuries and building damage that might otherwise have occurred during the Loma Prieta Earthquake.

### **San Francisco Earthquake Safety Program**

City and County General Fund departments own about 550 buildings. (This does not include those owned by the Unified School District, the Housing Authority, Airport, Port, and Water Department.) Their replacement value is estimated at more than \$4 billion in 1992. The average age of San Francisco's municipal buildings is more than 50 years. Many have historical or architectural value. Guaranteeing the functioning of some of these buildings is important because they house city operations, provide temporary shelter or other emergency services that are critical throughout a disaster period.

Since its inception in 1988, the City, through its Earthquake Safety Program, has inspected 202 General Fund supported buildings for seismic hazards. Inspected buildings were rated on a scale ranging from 1 (minor damage), 2 (moderate damage), 3 (major damage) to 4 (collapse potential). Of the buildings evaluated, (which included those expected to be most vulnerable or containing critical functions), almost half are expected to sustain major damage or collapse in a large earthquake. They included Fire Department facilities, most of the Civic Center administrative buildings, branch libraries, police facilities, and many buildings at San Francisco General and Laguna Honda Hospitals.



City residents approved bonds in 1987, 1988, 1989 and 1990 to fund earthquake repair, retrofit, and related improvements for City buildings. Buildings are now being reinforced, with higher priority assigned to:

- facilities containing critical functions
- unreinforced masonry buildings (considered serious hazards)
- high occupancy buildings
- those with an ornate, monumental style of architecture that will be difficult to repair or replace when damaged

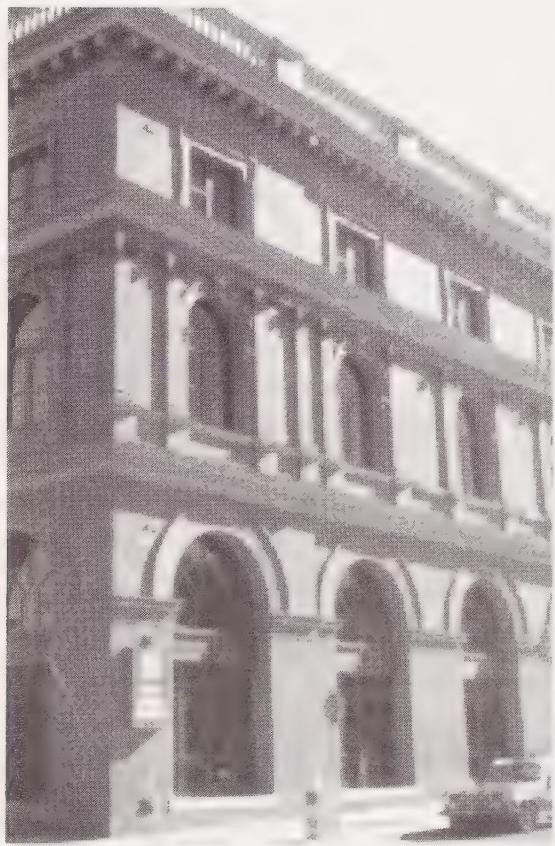
Earthquake Safety Program, Phase I includes 23 buildings, 19 of them fire stations. Fifteen of the Phase I buildings are complete. The remaining eight are in the planning, programming and design phase. Phase II includes 191 projects focusing on the repair of damage from the Loma Prieta earthquake and structural upgrades. 172 of the 191 projects are complete. Planning, programming, design and construction work is underway for seismic retrofit projects at the five major Civic Center buildings.

Civic Auditorium is nearing completion. Construction is underway at City Hall and at the War Memorial Opera House. The Department of Public Health headquarters at 101 Grove Street and the Veterans' Building are in the design phase.



**Seismic retrofit of Civic Auditorium, 1995.**

Photo: San Francisco Department of Public Works, Bureau of Architecture.



#### **Retrofitted Unreinforced Masonry Building.**

Photo: California Office of Emergency Services, Coastal Region.

There are other important City-owned buildings which present seismic risks, but for which funding for retrofit or replacement has not yet been secured. Among the most critical are nine subsidiary buildings at the Laguna Honda Hospital complex and 18 at the San Francisco General Hospital complex that are vulnerable to severe earthquake damage. The Hall of Justice is also vulnerable. These projects will probably be the subjects of bond proposals on future ballots.

#### **Unreinforced Masonry Building Hazard Reduction Program**

In 1992 the City established a program to reduce hazards in privately-owned unreinforced masonry buildings. It amends the Building Code and other City codes to set standards for the mandatory retrofit of UMBs. It set deadlines for the work, based on the location and use of the building, which range until the year 2006, depending on the severity of the hazard. San Francisco voters passed a \$350 million bond issue to establish a loan fund to assist owners to carry out the work.

Several important policy issues were raised while considering options for reducing the UMB hazard. Many UMBs contain low-income housing and small businesses, uses that could not support higher rents resulting from seismic retrofit. Many UMBs are older buildings of architectural or historic interest. The City's UMB program is an attempt to improve life safety, while recognizing these important issues. In order to achieve this balancing, lower standards apply to UMB retrofits than would apply to retrofit triggered by a change of use or substantial alteration.

## **Building Retrofit Programs in Other Localities**

Since the 1994 Northridge earthquake, cities in Southern California have considered and enacted ordinances requiring the retrofit of privately-owned buildings, in addition to unreinforced masonry buildings. The City of Santa Monica now requires the retrofit of non-ductile concrete, soft-story, and tilt-up buildings. The City of Los Angeles requires the retrofit of tilt-up structures. The Los Angeles Department of Building and Safety is developing proposals to require the retrofit of soft-story, and non-ductile concrete frame buildings. These proposed ordinances will be considered by the City Council in 1996. Los Angeles has also passed an ordinance requiring the inspection of some steel-frame buildings which may have been damaged in the Northridge earthquake, and the repair of damaged steel connections.

The Cities of Los Angeles and San Leandro have developed information programs to encourage owners of small wood-frame homes to bolt the buildings to their foundations.

## **Retrofit Programs for Highways and Bridges**

Some of the most serious, and some of the most visible, damage from recent earthquakes, including the Loma Prieta, Northridge and Kobe earthquakes, was suffered by bridges and highways. Bay area bridges and viaducts remain vulnerable to damage during a large earthquake. Caltrans has investigated all of the 12,000 state-owned bridges and plans to retrofit the bridges that are most vulnerable to collapse during a maximum credible earthquake. (A maximum credible earthquake is the largest earthquake that scientists believe local faults could produce. It is larger than the likely, and more frequent earthquakes that scientists expect to occur in the next 30 years.) About 1,450 of the state's 12,000 transportation structures require retrofit under this standard, with another 875 still in the analysis/design process. Caltrans' goal is to have all construction work completed on these bridges by December 1997.

Caltrans also has a program to retrofit about 1,000 locally-owned structures of the approximately 12,000 locally-owned bridges in the state. As of May 1995, construction was complete for 27 and underway on 34. The rest are in the analysis and design process.



Caltrans bridges are being retrofit to assure that they do not collapse, risking lives. Except for toll structures, they are not being retrofitted to assure that they will be usable after a maximum credible earthquake, unless the cost for full serviceability is close to the cost of retrofitting for no collapse. But because the maximum credible earthquake is a high design standard, Caltrans expects that most structures will be serviceable to various degrees after lesser magnitude, but more frequently occurring, earthquakes. The Bay Bridge, because of its critical role in the region's transportation system, will be retrofitted to a standard higher than no collapse. Caltrans is currently analyzing the cost and benefits of different engineering approaches to the retrofit of the Bay Bridge and its approaches. Construction is underway on the east approaches to the Bay Bridge. Caltrans expects to complete retrofit of the east spans of the bridge by December 1997.

The Golden Gate Bridge District is planning a retrofit of the Golden Gate Bridge and its approaches. The work is intended to allow the bridge to withstand the maximum credible earthquake, be serviceable for emergency vehicles and open to traffic within a few days. The work will occur in five independent phases over the course of five years. The District will supply 20% of the \$175 million cost and is seeking federal funding for the rest.

### **Lifelines**

Because of its age and its underground location, the City's water system is vulnerable to damage from earthquakes. The San Francisco Water Department is replacing weak, brittle cast iron water mains, installed between the 1850s and 1938, with new mains of ductile iron, which is more resistant to earthquake forces. Mains in areas with poor soils will be replaced first. 35,000 linear feet are replaced each year. However, because there are about 1000 miles of cast iron pipe in the City, replacement will take many years.

The Water Department also has an ongoing project of installing gate valves, which compartmentalize the system and shorten the length of pipe taken out of service when mains break. These programs will help to maintain domestic water service after an earthquake, and will, over time, reduce the number of fire hydrants out of service because of main breaks.

Pacific Gas and Electric Company has an ongoing program to reduce earthquake vulnerability of the gas and electric systems. It includes ongoing assessment of earthquake hazards, mitigation, and emergency planning. It found that the greatest vulnerability of the gas system was in areas of soft soils and older, brittle pipe. As a result, PG&E modified its 25-year Gas Pipeline Replacement Program to place higher priority on replacement of pipe within these vulnerable areas. It found that the most vulnerable parts of the electric system are substations. In response, PG&E is undertaking programs to replace selected circuit breakers, upgrade substation control buildings and improve the emergency response capabilities of substations. Actions taken to reduce disruptions to PG&E's Northern California gas and electric systems are described in annual reports on the *Program to Reduce Earthquake Vulnerability of the Gas and Electric Systems by the Year 2000*.

Dams and reservoirs which hold large volumes of water represent a potential hazard due to failure caused by ground shaking. The operation, maintenance and post-earthquake inspection of dams and reservoirs generally 25 feet or more in height or impounding 50 acre-feet of water or more, are regulated by the California Department of Water Resources, Division of Safety of Dams (DOSD). The areas that would be inundated by a total catastrophic failure of these facilities are filed with the California Office of Emergency Services. The San Francisco Water Department owns six reservoirs within San Francisco in this category, including Stanford Heights Reservoir, Sunset Reservoir (North and South), Sutro Reservoir and University Mound Reservoir (North and South). Their inundation areas are shown in Map 7. In-place drainage facilities at these locations, reducing the likelihood of inundation. The San Francisco Water Department monitors its facilities by surveying to detect any movement and monitoring ground water, and submits periodic reports prepared by a staff registered engineer to the DOSD.

The San Francisco Water Department also operates six dams outside of San Francisco, in Alameda, Santa Clara and San Mateo counties. The Alameda, Santa Clara and San Mateo County Emergency Response Plans consider the potential risks posed by the dams within their areas of responsibility.



## NON-STRUCTURAL MITIGATION

Most of the programs described in this chapter address problems posed by hazardous buildings and other structures. Non-structural hazards also pose a substantial risk to people, and a potentially huge financial loss during earthquakes. Non-structural systems installed during the construction process, such as suspended ceilings and lighting, HVAC and sprinkler systems, should be securely anchored so that they do not fall during earthquakes. Many of these systems are regulated by the San Francisco Building Code.

Other non-structural elements such as office equipment, computers, inventory, furnishings are arranged and rearranged by all of us in the course of everyday life. The only effective approach to the mitigation of these hazards is to raise public awareness. FEMA has produced a booklet on mitigating non-structural damage in commercial buildings, *Reducing the Risks of Non structural Earthquake Damage: A Practical Guide* (publication #FEMA74), and developed handout materials on specific non-structural hazards. (Many of these publications can be obtained by calling California Office of Emergency Service's Information Line: 1-800-286-SAFE.) The U.S. Geological Survey's widely distributed *The Next Big Earthquake in the Bay Area may come sooner than you think* also contains information on reducing non-structural damage in the home.



**Non structural damage.**

Photo: California Office of Emergency Services, Coastal Region.



## **P R E P A R E D N E S S   A N D   R E S P O N S E P R O G R A M S**

Response activities encompass the immediate actions taken to save lives, provide care for the injured, protect property, and provide for the basic needs for water, food, shelter and information in the wake of a disaster. Preparedness includes planning, education, and training for these actions. Each of these categories includes activities undertaken by emergency responders like police, firefighters, paramedics, other government agencies, community-based organizations, families, businesses, and individuals.

### **EMERGENCY RESPONSE BY SAN FRANCISCO AGENCIES**

Planning for response to emergencies is largely the responsibility of local government. The first responders and those with lead responsibility during the response phase of a major disaster are the same agencies that have a day-to-day responsibility for responding to emergencies: the Fire Department, Emergency Medical Service of the Health Department, the Police Department, the Department of Public Works, the Department of Parking and Traffic. However, during periods of greater emergency the needs for assistance are more extensive than the resources usually available to responders. This may be considered on its face the definition of a disaster. During and after a disaster additional organizations, both City agencies and other responders, are called into service in a unified command structure, as is required by State law. Inter-agency coordination is critical to an effective response.

The San Francisco Administrative Code establishes a Disaster Council with responsibility "for the preparation and carrying out of plans for the protection of persons and property . . . in the event of an emergency." Its members include the Mayor, the CAO, the directors of City departments with responsibilities during a disaster, three members of the Board of Supervisors, and others appointed by the Mayor. In addition, three subcommittees have been formed: a Neighborhood Preparedness Advisory Committee consisting of community representatives with an interest in disaster preparedness; a Business Preparedness Advisory Committee which develops outreach to businesses; and a Vulnerable Populations Advisory Committee which advises on preparedness and response issues as they affect the disabled, the elderly and other vulnerable groups.



## **Mayor's Office of Emergency Services**

The Administrative Code also creates an Office of Emergency Services (OES) with a Director appointed by the Mayor. The OES is responsible for developing, managing and coordinating the response to emergencies, and for developing an Emergency Plan. The City's OES currently has four professional staff members in addition to its Director.

The Emergency Operation Plan (EOP) is the City's blueprint for emergency response. An EOP was adopted in 1987. A task force with representatives of City departments and other organizations with emergency responsibilities, coordinated by the OES, is currently updating the EOP. As required by State law, the new EOP incorporates the Standardized Emergency Management System (SEMS) to facilitate communications and cooperation between City agencies, other jurisdictions and levels of government. The new EOP will be presented to the San Francisco Board of Supervisors in 1996.

The revised EOP will include:

- Descriptions of the city's emergency management systems.
- Checklists to guide emergency managers and assure that response procedures are clear and consistent.
- Responsibilities of lead and support departments in different types of emergencies. (See Table 2.)
- Guidance to Departments for their operational planning

The EOP will be periodically tested in exercises, and updated as circumstances require. Each response department has or will develop its own emergency plan to guide it and supporting departments, in carrying out specific responsibilities.

## **San Francisco Fire Department**

A critical City response function is the suppression of major post-disaster fires, and one of the critical factors in fire-fighting, especially after earthquakes, is the availability of water. In 1906, there was extensive damage to the underground Municipal Water Supply System (MWSS), crippling the response to the fire that followed the earthquake. Extensive damage to the underground water system which supplies potable water for homes and businesses, and is

The following table shows major emergency response functions and the City Departments assigned as Lead for each function:

**TABLE 2**

<b>Function</b>	<b>Lead Department</b>
Alert and Mobilization	OES
Public Information	OES and Mayor's Office
Legal Advice	City Attorney's Office
Situation Analysis	Planning Department
Evacuation	Police Department
Fire	Fire Department
Search and Rescue	Fire Department
Law Enforcement	Police Department
Health and Medical	Department of Public Health
Route Recovery/Street Clearance	Department of Public Works
Utilities	Department of Public Works
Traffic Management	Department of Parking and Traffic
Fuel Allocation	Public Utilities Commission
Fatality Management	Medical Examiner
Construction/Engineering	Department of Public Works
Schools	SF Unified School District
Care and Shelter	American Red Cross
Resource Management	Chief Administrative Officer
Supplies and Equipment	Purchasing Department
Communications	Department of Electricity and Telecommunications
Human Resources	Department of Human Resources
Transportation	Department of Transportation
Recovery	Planning Department

Other City Departments provide support.

Source: San Francisco Emergency Operations Plan, 1995.



**Portable Water Supply System in operation in Marina District, 1989.**

Photo: © 1995 Michael Mustacchi and Associates

usually used for fire fighting, is likely during an earthquake. In the years after 1906, the City developed a series of backup water systems for firefighting. The Auxiliary Water Supply System (AWSS) is a separate and redundant water system designed specifically to provide water for firefighting when the MWSS is damaged. About 175 underground cisterns, with an average capacity of 75,000 gallons, have been built throughout the City. A Portable Water Supply System (PWSS) has been developed. PWSS is a system of portable large diameter hose, connections, and pumps

intended to bridge breaks in the underground systems and to use lake, bay and cistern water when other water is not accessible. A 1986 Bond funded program added an electronic monitoring and operations system for the AWSS, 33 Bay water suction devices to provide water for firefighting in areas along the Bay front, 26 new cisterns, expansion of the PWSS, extension of the AWSS. A second fire boat has been acquired. Most of these improvements were "on the drawing board" at the time of the 1989 earthquake; most are now complete.

### **Community-based Organizations**

Community-based organizations, especially the American Red Cross, play active roles in planning and providing for the provision of basic human needs such as food and shelter after a disaster. The San Francisco Administrative Code and the Emergency Operations Plan give the Red Cross, in cooperation with City agencies, primary responsibility for providing post-disaster shelter to those displaced by a disaster. The Red Cross trains volunteers, establishes and manages shelters in locations designated in the EOP, and delivers other support services.

A group of community based organizations and public agencies have formed the San Francisco Collaborating Agencies Responding to Disasters Project (CARD) to conduct interagency planning and preparedness activities, assist community-based organizations in preparing response plans, provide an ongoing forum for communication and information sharing, and ensure interagency coordination with local government and Red Cross during a major disaster. One of CARD's first projects was to develop a plan to use volunteers effectively after a disaster.



## PUBLIC PREPAREDNESS

Public agency emergency responders and the non-governmental agencies that are part of the City's Emergency Operations Plan will not be able to respond adequately to every critical situation after a major disaster. Consequently, members of the public, businesses, and other organizations must be prepared to help themselves and each other, especially in the first 72 hours.

Since 1990, the Fire Department has conducted a specialized program designed to train people, on an individual and team basis, to respond effectively following disasters when the usual emergency responders are unavailable. The program, Neighborhood Emergency Response Teams (NERT), consists of five three-hour classes addressing first aid, small fire extinguishment, light search and rescue techniques, damage assessment, utility control (when and how to shut off gas, water and electricity), and team operations. It emphasizes the importance of neighbors working together and looking out for one another. Classes are taught by firefighters. As of May 1995, about 3500 people in neighborhood groups have completed the training. Periodically, classes are conducted for City employee and business groups.

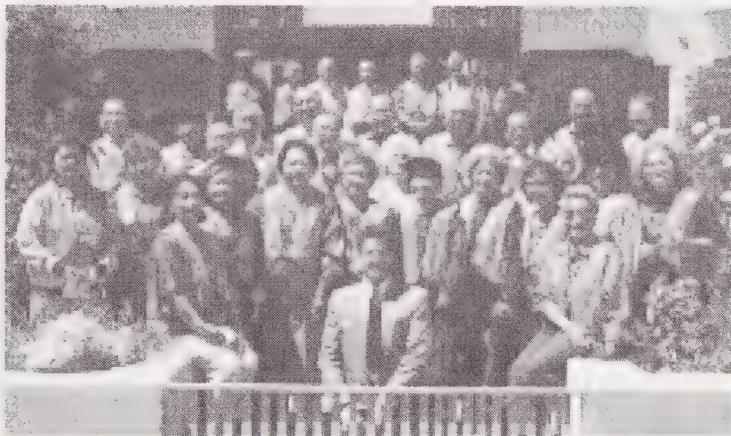
The Mayor's Office of Emergency Services has recently begun a program to promote and facilitate greater public preparedness. A Neighborhood Preparedness Coordinator promotes awareness of disaster risks, informs residents, property owners, businesses, and other organizations about disaster preparedness, including ways to make homes and businesses safer before a disaster occurs, preparing family plans, stocking water, food and personal needs. The program will coordinate the outreach efforts of various City agencies, and will cooperate with community-based organizations.

The American Red Cross also conducts classes and training for the public, businesses, and organizations to help them prepare for and respond to emergencies and disasters. These classes include first aid and CPR training, Living on the Fault Line (earthquake preparedness), and training for disaster relief workers in Shelter Operations, Damage Assessment, Disaster Health Services, and other functions. Over 20,000 people receive Red Cross emergency training in San Francisco each year. In addition, Red Cross volunteers



**NERT Training**

Photo: © 1995 Michael Mustacchi and Associates



**TODCO disaster preparedness team.**

Photo: TODCO

provide community disaster preparedness education through presentations, exhibits, events and publications including brochures, posters, checklists and the video *Earthquake! Do Something!* available in seven languages. Several community-based organizations and neighborhood groups are working to increase neighborhood-based preparedness and response capabilities. The Chinatown and South of Market communities are among the most active. Both have hired neighborhood planners to coordinate community preparedness efforts. These efforts recognize that preparedness can only be achieved through ongoing education. They emphasize the importance of individual preparedness. The NICOS Chinatown Disaster Response Steering Committee, which includes representatives of community-based organizations, holds periodic drills to familiarize residents with safety issues and the emergency plan, to exercise communications resources and neighborhood medical facilities. These exercises have been combined with community forums and Chinese language information campaigns in Chinatown.

The Tenants and Owners Development Corporation (TODCO), a South of Market non-profit low income housing developer has developed the Yerba Buena Neighborhood Earthquake Preparedness Program. The program involves residents, service providers, and disaster response agencies in this multi-lingual, multi-cultural, community with significant numbers of elders and disabled residents. A plan has been prepared; it was tested in an April 1995 exercise, and a final plan released based on experiences of that exercise.

TODCO has also developed an Earthquake preparedness video *Make Yourself A Promise*. It focuses on individual preparedness, neighborhood planning and vulnerable populations. It is available in ten languages: English, English open-captioned, Cantonese, Mandarin, Russian, Spanish, Korean, Cambodian Vietnamese and Tagalog.



## RECOVERY AND RECONSTRUCTION PROGRAMS

### FEDERAL AND STATE FINANCIAL ASSISTANCE PROGRAMS

Most existing federal and state disaster recovery programs are intended to restore the physical facilities that existed before the disaster, and provide financial assistance for interim housing. In recent years, there has been a growing trend from federal and state agencies to devote some post-disaster funding to hazard mitigation in order to decrease the impacts of future disasters. The programs, and their implementation, have evolved over the course of the many major disasters during the last several years. Consequently, even without a local disaster, it is important for local governments to remain informed about the current regulations and processes that will guide federal and state recovery programs.

After the 1989 Loma Prieta earthquake, assistance from these programs to the San Francisco Bay Area totaled approximately \$1 billion. As of mid-1995, about \$9 billion was committed to these same programs in response to the 1994 Northridge earthquake.

**Public Assistance Programs.** Public assistance programs fund the repair and reconstruction of public facilities. They also help nonprofit agencies that provide public services. Applications are made through the California OES to FEMA. San Francisco's experience with these programs since 1989 has been that the application and appeal processes can be extremely detailed and time-consuming. As of June 1995, more than five and one-half years after the Loma Prieta Earthquake, FEMA has approved about \$300 million in repair costs.

**Hazard Mitigation Grants.** The federal Public Assistance programs set aside disaster funds to be used by local agencies to reduce the losses from future disasters. These grants are made following the preparation of a local *Hazard Mitigation Plan*, and are allocated by the state with FEMA approval. In 1989, 10% of the amount of FEMA's Public Assistance damage repair cost was committed to local agencies for hazard mitigation. Localities had to commit 50% of the total costs of projects. For the Loma Prieta earthquake this totaled about \$60 million for the ten counties and two cities that were within the



declared disaster area. Although over five years have past since the Loma Prieta earthquake, \$15 million of this hazard mitigation fund remains to be allocated to local jurisdictions by FEMA. Hazard mitigation grants of seven million dollars has been approved for San Francisco projects. San Francisco projects totalling about \$13 million are awaiting FEMA approval. Applications have been submitted for an additional \$10 million.

As a result of the new emphasis on hazard mitigation, the allocation formula has changed since 1989. Current regulations allocate 15% of all FEMA disaster funding to hazard mitigation. Local agencies need to provide 25% of the funding of approved projects.

*Individual assistance programs.* Federal programs provide housing assistance, loans and grants to tenants, homeowners, and businesses whose buildings or personal property were lost or damaged. A variety of agencies are involved. After the Loma Prieta earthquake, coordination between these agencies, and with State agencies involved in the administration of federal programs, was not always smooth, sometimes leading to delays. Inspectors did not recognize local costs and often underestimated the costs of reconstruction. Federal loan programs administered by the Small Business Administration have a loan ceiling that may not provide for reconstruction in this high-cost region. For example, after Loma Prieta the ceiling for businesses, including multi-unit rental housing, was \$500,000.

Federal programs provide temporary housing assistance for households displaced from their homes. This program consists primarily of subsidies to be used in the private rental market. Even after the 1989 Loma Prieta earthquake and the 1991 East Bay Hills fire, where relatively small percentages of the regional housing stock were destroyed, the private rental market did not always have sufficient vacant units to provide housing for those displaced. After the Loma Prieta earthquake, about 2,500 households received temporary housing assistance. Where private rental housing is not available, FEMA may provide temporary housing, such as mobile homes or other readily fabricated dwellings for disaster victims.

Federal programs do not generally include incentives to replace lost rental housing units. As a result, while most of the housing units lost in the Marina district during Loma Prieta were rental units, most of the replacement units are condominiums.

***Redevelopment Law.*** The *Community Redevelopment Financial Assistance and Disaster Project Law* provides for the expedited designation of a redevelopment project area where there has been a Presidentially-declared disaster. The law is not specific about the kinds of redevelopment activities that can be undertaken in these redevelopment areas. Requirements for preliminary plans, public notice, and Planning Commission involvement are eased or eliminated. Relocation requirements are waived, but the legislative body must find that the plan encourages “to the maximum extent feasible . . . the provision of dwellings suitable for the needs of families displaced by the disaster or by redevelopment, rehabilitation or renewal activities.” Local governments seldom use this process. Instead special State legislation meeting the specific needs of the area and responding to specific damage are sought. For example, downtown Santa Cruz was made into a redevelopment area under special state enabling legislation. San Francisco’s use of this provision is described below.

## **SAN FRANCISCO RECONSTRUCTION POLICIES AND PROGRAMS**

Local recovery policies and programs do not provide direct financial assistance to victims. Instead, they set the rules that govern rebuilding efforts, whatever the financing used. The 1974 Community Safety Element includes a broad objective: “Assure the sound and rational reconstruction of San Francisco following a major disaster.” It establishes a City policy that rebuilding should be in accordance with established Master Plan objectives and policies; that contingency legislation be adopted; and that a Reconstruction Planning Committee be appointed before a disaster occurs. These last two policies have not been implemented.



Following are various City ordinances that apply generally to disasters, or that were enacted specifically in response to the Loma Prieta earthquake. A larger earthquake could pose quite different issues.

### **San Francisco City Planning Code**

Section 181(d) of the City Planning Code allows the reconstruction of buildings that do not conform to the current Planning Code, if they are destroyed by “fire, or other calamity, or by Act of God, or by the public enemy,” and are rebuilt within one year. This provision, common in zoning ordinances, was enacted to ensure that owners whose buildings are destroyed by fire or in some other way not of their doing, can rebuild a similar building even if the Planning Code regulations have changed since the structure was built. Such reconstructions typically must comply with the current Building Code. There has not been a situation where there has been widespread destruction and subsequent non-conforming rebuilding under this City Planning Code provision.

### **San Francisco Earthquake Emergency Permit Procedure.**

After the Loma Prieta earthquake, the Board of Supervisors adopted an emergency ordinance to expedite the repair or replacement of damaged residential buildings. This ordinance:

1. allowed developers of replacement buildings to seek authorization to increase the size of the new building beyond the damaged building and beyond the size that would otherwise be permitted under the Planning Code, if the increase results from Building Code requirements. For example, the Building Code might require additional exit stairs.
2. allowed owners of replacement buildings to seek exemptions from other City Planning Code provisions needed because of Building Code requirements. For example, needed seismic strengthening might reduce the space available for required parking.
3. gave the tenants occupying the unit at the time of the emergency the right to reoccupy units repaired or rebuilt under the ordinance, and in some cases brought otherwise exempt repaired or rebuilt units under the Rent Control ordinance.

Permits issued pursuant to this ordinance had a shortened public notice and review process. Ten owners were granted the larger size described in item 1 above. Five owners were granted the reduced parking described in item 2 above. (The Loma Prieta earthquake severely damaged or destroyed about 85 residential buildings.) Most private residential buildings destroyed were rebuilt as condominiums to obtain financing. The need to rebuild as condominium unit may have contributed to owners' decisions not to use this process, which might have subjected them to the Rent Control ordinance. The Earthquake Emergency Permit Procedure ordinance expired October 17, 1992.

### **San Francisco Earthquake-Damaged Illegal Units Legislation.**

In 1990, Section 181(d) of the City Planning Code was amended to allow the restoration of previously existing housing units that had not existed legally before the Loma Prieta earthquake. It allows the rebuilding of illegal units, if it can be proved that the unit was occupied within one year before October 17, 1989, and if the unit can be brought into compliance with the Building Code, the Housing Code, the Fire Code, and State and Federal law. All such restored units must be offered to the previous tenant. If that tenant declines, they must be offered at the previous rent, or if the previous rent cannot be established at a rent affordable to households making 80% of the median San Francisco income. Four previously unrecorded residential units were rebuilt and legalized under this provision.

### **South of Market Redevelopment Project.**

The Community Redevelopment Financial Assistance and Disaster Project Law described above provides for redevelopment projects in areas impacted by natural disasters. Following the Loma Prieta Earthquake, the City adopted an emergency redevelopment area in the South of Market area, along the Sixth Street corridor. This area contains many small residential units and single-room occupancy (SRO) hotels. Some buildings were (and are) poorly-maintained and in need of upgrade, but nonetheless represent an important housing resource for low-income people. Nearly 500 of the area's housing units were lost in the earthquake.



Redevelopment law provides little guidance as to the kinds of activities that can be undertaken in these redevelopment areas. San Francisco officials limited the application of the emergency redevelopment area to the individual properties that sustained physical damage. Because City goals go beyond repairing earthquake damage, seeking to improve and expand the housing in the area, the City is in the process of establishing the area as a conventional redevelopment project. About 1600 new or rehabilitated family and small size units, and 600 new SRO units are planned. Many of these units will be owned and operated by local nonprofit corporations. The plan also includes new commercial and industrial space, a business development loan program and public improvements. As of August 1995, 228 units were completed, 109 were under construction and 230 were in the pre-development process.

#### **New Construction in South of Market Redevelopment Area**

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Photo: San Francisco  
Redevelopment Agency



## PRE-DISASTER RECOVERY PLANNING IN OTHER LOCALITIES

Safety Elements in some other jurisdictions include recovery and reconstruction policies. The Los Angeles County *Safety Element*, adopted in 1990, recommends the establishment of a "Los Angeles County Reconstruction Authority" and includes a draft ordinance. The Authority would be created before a disaster, and would begin establishing procedures for the post-disaster phase as soon as it was formed. Its charge would be "to facilitate reconstruction of structures and facilities destroyed or damaged during a major earthquake; provide special procedures to expedite public and private recovery activities; guard against reconstruction which could result in future peril to life or property; encourage the improvement of the environment where new opportunities have been created by severe property damage and enable the County of Los Angeles to cooperate more effectively with other local jurisdictions, and agencies of the State and the Federal governments during reconstruction." The Los Angeles County Reconstruction Authority has not been established.

The Emergency Operations Organization of the City of Los Angeles approved a *Recovery and Reconstruction Plan* in 1994. It was prepared by the Recovery and Reconstruction Subcommittee, of the City's Emergency Operations Organization. (This EOO is described in more detail below.) The Recovery and Reconstruction Plan is "based on the premise that successful recovery and reconstruction is dependent on systematic pre-earthquake planning for the restoration of services, housing and economic vitality." Its topics include:

- Residential, Commercial and Industrial Rehabilitation
- Public Sector Services
- Economic Recovery
- Land Use/Re-Use
- Organization and Authority
- Psychological Rehabilitation
- Vital Records
- Interjurisdictional Relationships
- Traffic Mitigation



Policies, and pre-disaster, short-term and long-term programs are included for each of these topics. Lead Departments are identified for each program.

### **POST-DISASTER RECONSTRUCTION PLANNING IN OTHER LOCALITIES**

Most cities do not have plans or procedures in place to guide post-disaster reconstruction. Downtown Santa Cruz was among the areas most severely impacted by the Loma Prieta earthquake. After the earthquake, Santa Cruz officials and citizens created a process which lead to the *City of Santa Cruz Downtown Recovery Plan*. The Plan evolved out of a 15-month-250-meeting process beginning with the establishment of a nonprofit corporation, “Vision Santa Cruz.” Vision Santa Cruz developed a set of generally-accepted “First Principles,” on which the plan was based. The plan established policies, standards and guidelines to direct the immediate and long-term recovery process. It included a land use plan that considered the economic potential for retail, housing and office uses, development standards and design guidelines; a plans for streetscape, circulation and parking, and open space.

Santa Cruz County passed a six-year, one-half cent sales tax to help fund recovery efforts, both public and private. All major private reconstruction projects included some level of public financial participation, from federal, state or county disaster assistance. Santa Cruz used redevelopment powers granted by special State legislation which, among other things, allowed a shortening of required processes, exempted the project from the California Environmental Quality Act, and reduced the base taxable value of property so that the amount of incremental property taxes available for the project would be greater.

After the 1994 Northridge earthquake, the City of Santa Monica created a Redevelopment Area using the State’s Community Redevelopment Financial Assistance and Disaster Project Law described above. The primary goal of the Redevelopment Area is to assist and encourage the repair and rebuilding of public and private facilities in the areas which sustained the most damage, and identify areas in which funding will be used.

## COMPREHENSIVE DISASTER PROGRAMS

To a greater degree than many other municipal functions, preparing for disasters requires coordination between individuals and agencies with different primary functions, missions, and skills. In San Francisco and in many other cities, this coordination has been informal and has evolved in response to current concerns and needs. While there are also many agencies involved in disaster issues at the state and federal levels, there is some consolidation of responsibility for natural disaster programs, including mitigation, preparedness, response and recovery, within the California Office of Emergency Services and the Federal Emergency Management Agency.

Some cities have taken the step of explicitly assigning the coordination of varied natural disaster programs to a single office. Berkeley has two staff people in the City Manager's office, including an Assistant City Manager, whose responsibilities include coordinating Berkeley's mitigation, preparedness, response and recovery programs.

In 1980, the City of Los Angeles established a multi-agency Emergency Operations Organization (EOO), under the direction of the Mayor and an Emergency Operations Board made up of department heads. An Emergency Operations Committee comprised of city agency representatives services as staff. The EOO was created by ordinance, "to centralize the direction and control of local emergency preparations, response and recovery," and is an on-going, annually funded part of the Los Angeles city government. The EOO Master Plan provides a framework for the city's disaster programs, including citywide emergency response coordination, departmental response plans, and annexes addressing specific issues, including Recovery and Reconstruction and Hazard Mitigation (in process). The EOO Master Plan and its components set forth the city's disaster policies and implementation programs and procedures. These plans are updated as needed by the EOO and are approved by the Mayor and adopted by the City Council.

The Safety Element of the Los Angeles City General Plan serves as a general guide to assist in the preparation and revision of the hazard mitigation and response and recovery annexes of the EOO Master Plan. The EOO Master Plan and its annexes implement the Safety Element.



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San Francisco, Department of Building Inspection, Zan Turner, Building  
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San Francisco, Department of Public Works, Laurence Kornfield, Chief  
Building Inspector, John Sucich, Finance Analyst.

TODCO, Jim West, Emergency Preparedness Planner, San Francisco.

Santa Monica, Department of City Planning, Paul Foley, Associate Planner.

Santa Cruz, Charles Eadie, Project Manager, Downtown Recovery Plan. (Now  
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